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Dash 8 Wet Runway Friction Measurement Program: February 2006

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by
Eric Texier, Frank Stastny and Eric Herrmann

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Since some of the accepted measures in the industry are imperial, metric measures are not always used in this report.

Un sommaire francais se trouve avant la table des matieres.

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Bombardier Aerospace, a unit of Bombardier Inc., participated in the Transport Canada Wet Runway Friction Measurement Program at Mirabel Airport in Quebec, Canada. During the period from September 7, 2005 to September 9, 2005, a de Havilland Dash 8 Series 400, test vehicle 4001, was provided by Bombardier Aerospace for the purpose of measuring braking friction coefficients on wet runway surfaces. Maximum braking tests were conducted to determine braking coefficients on a wet runway using differential global positioning system (DGPS) speeds and distances, with a brakeless test conducted to validate the aircraft propeller drag model. The results of this study will be used to provide a more comprehensive understanding of aircraft operating from wet runways in an effort to improve safety.

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16. Résumé

Bombardier Aéronautique, une composante de Bombardier Inc., a participé au Programme de mesure du frottement sur pistes mouillées de Transports Canada, en mettant à sa disposition un de Havilland Dash 8-400 (véhicule de présérie 4001). Du 7 au 9 septembre 2005, des essais ont été menés à l'aéroport de Mirabel, Québec, Canada, afin de mesurer les coefficients de frottement de freinage sur pistes mouillées. Des essais de freinage maximal ont eu lieu pour déterminer les coefficients de freinage sur pistes mouillées à partir des vitesses et distances établies par un système de positionnement global différentiel (DGPS). Un essai sans freinage a aussi été mené, afin de valider la traînée d'hélice théorique de l'appareil. Les résultats de cette étude serviront à approfondir notre compréhension du comportement des avions exploités sur des pistes mouillées, dans le but ultime de rendre le transport aérien plus sûr.

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EXECUTIVE SUMMARY

Bombardier Aerospace, a unit of Bombardier Inc., participated in the Transport Canada Wet Runway Friction Measurement Program at Mirabel Airport in Quebec, Canada. During the period from September 7, 2005 to September 9, 2005, a de Havilland Dash 8 Series 400, test vehicle 4001, was provided by Bombardier Aerospace for the purpose of measuring braking friction coefficients on wet runway surfaces. Maximum braking tests were conducted to determine braking coefficients on a wet runway using differential global positioning system (DGPS) speeds and distances, with a brakeless test conducted to validate the aircraft propeller drag model. The results of this study will be used to provide a more comprehensive understanding of aircraft operating from wet runways in an effort to improve safety.

Tests were performed at Mirabel Airport, Quebec, Canada (airport code CYMX), elevation 259 ft MSL (mean sea level). All tests were conducted on runway 11/29. Mirabel Airport was chosen for the wet runway analysis due to the fact that the condition of the runways was near the minimum maintenance standard. The two test sections, one located at each end of the runway, were positioned on the parts of runway 11/29 that had the most rubber deposits.

On September 8, 2005 at Mirabel Airport, natural rain wet the runway surface for much of the testing; with only the first test point requiring the use of a tanker truck. The rain was heavy at times, resulting in conditions deemed beyond the definition of "wet runway". However, ground crew present throughout the testing monitored the water on the runway to confirm it was no more than 3 to 4 mm deep. The crown on the runway provided good drainage despite the heavy rain.

The objective of the flight tests was to determine the braking friction coefficient on a wet runway near the minimum maintenance standard in order to substantiate the current operational factor for wet runways. Braked tests were performed for accelerate-stop and landing manoeuvres, and a brakeless test was performed for an accelerate-stop. The brakeless test was done in order to validate the propeller drag model, the aircraft aerodynamic drag and rolling coefficient of friction. For this test the aircraft was allowed to decelerate through the test section without wheel braking. The result from the brakeless accelerate/stop test shows the propeller drag to be in conformity with the certified propeller drag model.

Braked tests were performed such that all braking occurred over the test area. Only the portion of the run where the brakes were operating at maximum antiskid effort was analyzed for brake friction. The effect of reduced runway friction on the transition from initial brake application to maximum effort was not considered.

The relationship between the brake friction coefficient and true groundspeed was determined for each of the six aircraft braking test points. All test points show a similar characteristic with groundspeed; however, the aircraft-derived wet braking friction for runway 11/29 at Mirabel was only about 50% of the braking coefficient levels of FAR 25.109 Amendment 92/JAA AMJ 25.1591. This is attributed to the smooth concrete surface and the condition of the runway throughout the test sections that showed heavy rubber deposits. These findings for the Dash 8 Series 400 are in line with those found during the Falcon 20 tests on this runway.

SOMMAIRE

Bombardier Aéronautique, une composante de Bombardier Inc., a participé au Programme de mesure du frottement sur pistes mouillées de Transports Canada, en mettant à sa disposition un de Havilland Dash 8-400 (véhicule de présérie 4001). Du 7 au 9 septembre 2005, des essais ont été menés à l'aéroport de Mirabel, Québec, Canada, afin de mesurer les coefficients de frottement de freinage sur pistes mouillées. Des essais de freinage maximal ont eu lieu pour déterminer les coefficients de freinage sur pistes mouillées à partir des vitesses et distances établies par un système de positionnement global différentiel (DGPS). Un essai sans freinage a aussi été mené, afin de valider la traînée d'hélice théorique de l'appareil. Les résultats de cette étude serviront à approfondir notre compréhension du comportement des avions exploités sur des pistes mouillées, dans le but ultime de rendre le transport aérien plus sûr.

Les essais ont été réalisés à l'aéroport de Mirabel, Québec, Canada (code d'aéroport CYMX), situé à une altitude MSL (niveau moyen de la mer) de 259 pi. Tous les essais ont eu lieu sur la piste 11/29. L'aéroport de Mirabel a été choisi pour les études sur pistes mouillées parce que l'état de ses pistes satisfaisait tout juste à la norme minimale d'entretien. Les deux tronçons d'essai étaient situés aux deux extrémités de la piste 11/29, zones particulièrement contaminées par des dépôts de caoutchouc.

Le 8 septembre 2005, il pleuvait à l'aéroport de Mirabel : la piste a donc été mouillée naturellement pendant presque toute la durée des essais; il n'a fallu l'arroser à l'aide d'un camion citerne que pour le premier point de mesure. La pluie était parfois si forte que les conditions outrepassaient la définition de «piste mouillée». Toutefois, l'équipe au sol, présente pendant toute la durée des essais, surveillait le film d'eau sur la piste pour s'assurer qu'il ne dépasse pas 3 à 4 mm d'épaisseur. Le bombement de la piste assurait un bon drainage, malgré la forte pluie.

L'objectif des vols d'essai était de déterminer le coefficient de frottement de freinage sur une piste mouillée dont l'état se rapproche de la norme d'entretien minimale, afin de valider le facteur opérationnel actuellement appliqué pour les pistes mouillées. Les essais de freinage ont été réalisés dans des situations d'accélération-arrêt et d'atterrissage, et un essai d'accélération-arrêt sans freinage a aussi eu lieu. Ce dernier essai avait pour but de valider la traînée d'hélice théorique, la traînée aérodynamique de l'avion et le coefficient de frottement de roulement. Pour cet essai, on laissait l'avion ralentir de lui-même sans appliquer les freins. Les résultats des essais d'accélération-arrêt sans freinage ont révélé une traînée d'hélice conforme à la traînée d'hélice théorique.

Pour les essais de freinage, les freins étaient appliqués sur toute la longueur du tronçon d'essai. Mais seule la portion de l'essai correspondant à la période de freinage avec antidérapage maximal a été retenue aux fins de l'analyse du frottement de freinage. L'effet du frottement moindre pendant la progression vers la force de freinage maximale n'a pas été pris en considération.

Le coefficient de frottement de freinage a été mis en rapport avec la vitesse sol vraie pour chacun des six points de mesure du freinage de l'avion. Tous les points de mesure indiquent une tendance similaire pour ce qui est de la vitesse sol; toutefois, le frottement de freinage sur surfaces mouillées mesuré à l'aide de l'avion pour la piste 11/29 à Mirabel atteignait à peine 50 p. 100 des coefficients de freinage prescrits dans le FAR 25.109, modification 92/JAA AMJ 25.1591. Cela est attribué à la surface de la piste en béton lisse et à l'état des tronçons d'essai, fortement contaminés par des dépôts de caoutchouc. Finalement, les résultats obtenus avec le Dash 8-400 corroborent ceux obtenus avec le Falcon 20 lors d'essais effectués sur la même piste.

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GLOSSARY OF TERMS

DGPS	-	**Differential Global Positioning System**
IAS	-	**Indicated Airspeed**
ITAS	-	**Integrated Telemetry Acquisition System**
METAR	-	**Metrological Report**
MSL	-	**Mean Sea Level**
SFT	-	**SAAB Friction Tester**
Vtas	-	**True Airspeed**
Vtgs	-	**True Groundspeed**

1.0 INTRODUCTION

Bombardier Aerospace, a unit of Bombardier Inc., participated in the Transport Canada Wet Runway Friction Measurement Program at Mirabel Airport in Quebec, Canada. During the period of September 7, 2005, to September 9, 2005, a de Havilland Dash 8 Series 400, test vehicle 4001, was provided by Bombardier Aerospace for the purpose of measuring braking friction coefficients on runway surfaces. The results of this study will be used to provide a more comprehensive understanding of aircraft operating from wet runways in an effort to improve safety.

2.0 TEST PROGRAM

2.1 Test Aircraft

Dash-8 Series 400, serial number 4001 was used to conduct the tests. This aircraft has been used by Bombardier Aerospace to conduct development and certification tests for the Dash-8 Series 400 product family. The aircraft was fitted with 2 Pratt & Whitney PW150A engines and 6-bladed Dowty Aerospace R408 variable pitch propellers. All tests were performed using a flap setting of 10°. A three view drawing of the aircraft is included in Appendix C.

2.1.1 Landing Gear

The aircraft has a conventional, retractable landing gear that is completely enclosed when retracted. The main landing gear is located in the engine nacelles which are positioned under a high wing. The main gear is equipped with dual wheels fitted with 34 x 10.75 -16 tubeless tires at 135 psi (unloaded) and 141 psi (loaded). The nose gear is also equipped with dual wheels which are fitted with 22x6.50 -10 tires at 85 psi (unloaded) and 89 psi (loaded). Only the main landing gear is fitted with brakes.

2.1.2 Antiskid Braking System

The aircraft is equipped with an Antiskid Braking System manufactured by ABSC. The ABSC Anti-skid System is a fully modulating system that uses an electronic control circuit to determine if the wheel is going into a skid. The control circuit reduces brake pressure when a skid is detected and increases it when the wheel recovers.

2.2 Aircraft Data Acquisition

The data acquisition system on the flight test aircraft was the ITAS which records a series of parameters on hard disc. The parameters used in the subsequent analysis are shown in Appendix A. The aircraft inertial position, provided by a NovAtel RT-20 Differential Global Positioning System (DGPS), was used to calculate aircraft groundspeed and deceleration.

2.3 Test Surface Description

Tests were performed at Mirabel Airport, Quebec, Canada (airport code CYMX), elevation 259 ft. MSL. All tests were conducted on runway 11/29. Mirabel Airport was chosen for the wet runway analysis due to the condition of the runways being near the minimum maintenance standard. The two test sections, one located at each end of the runway, were positioned on the parts of the runway 11/29 that had the most rubber deposits. Appendix D shows the runway surface in the test section of runway 11 with the heavy rubber deposits.

On September 8th, 2001 at Mirabel Airport, natural rain wet the runway surface for much of the testing; with only the first test point requiring the use of a tanker truck. The rain was heavy at times, resulting in conditions deemed beyond the definition of "wet runway". However, ground crew present throughout the testing monitored the water on the runway to be no more than 3 to 4 mm deep. The crown on the runway provided good drainage despite the heavy rain.

2.4 Aircraft Tests

The objective of the flight tests was to determine the braking friction coefficient on a wet runway near the minimum maintenance standard to substantiate the current operational factor for wet runways. Braked tests were performed for accelerate-stop and landing manoeuvres, and a brakeless test was performed for an accelerate-stop. The brakeless test was done in order to validate the propeller drag model, the aircraft aerodynamic drag and rolling coefficient of friction. For this test the aircraft was allowed to decelerate through the test section without wheel braking. Appendix D shows pictures of the Q400 participating in the wet runway friction measurement program at Mirabel.

Braked tests were performed such that all braking occurred over the test area. Only the portion of the run where the brakes were operating at maximum antiskid effort was analyzed for brake friction. The effect of reduced runway friction on the transition from initial brake application to maximum effort was not considered.

2.5 Ground Vehicle Tests

Two vehicles were used to measure the brake friction of the wet surfaces. These were a Transport Canada SAAB Friction Tester (SFT) and a Tradewind Scientific Inc. SFT. The ground vehicle test runs were performed both prior to and after each aircraft run. This was done to allow comparison between the ground friction measuring devices and the brake friction calculated from the aircraft data. The SFT data and the aircraft calculated braking friction as functions of distance can be seen in Appendix E.

2.6 Analysis Methods

The brake friction coefficients were derived from the overall retardation force obtained from the DGPS-based deceleration, minus the rolling friction model, the airframe drag model, the propeller drag model and the weight component due to runway gradient. The appropriate equations are detailed in Appendix A of Reference B. The DGPS ground speed data were curve fitted with a polynomial, and differentiated to get the deceleration.

Although wind station data were recorded by the ITAS throughout testing, the data were found to be unusable. Therefore, the wind speed, affecting the propeller drag and aircraft lift and drag calculations were derived from Vtas-Vtgs, averaged over the time duration of each test point, with Vtas based on ship IAS. The derived head wind data were compared to the head wind data calculated from the recorded Mirabel Airport tower winds (METAR). The comparison of wind speeds can be seen in Figure 1. The tower wind data were not used for the analysis due to the low sampling rate in the METAR database.

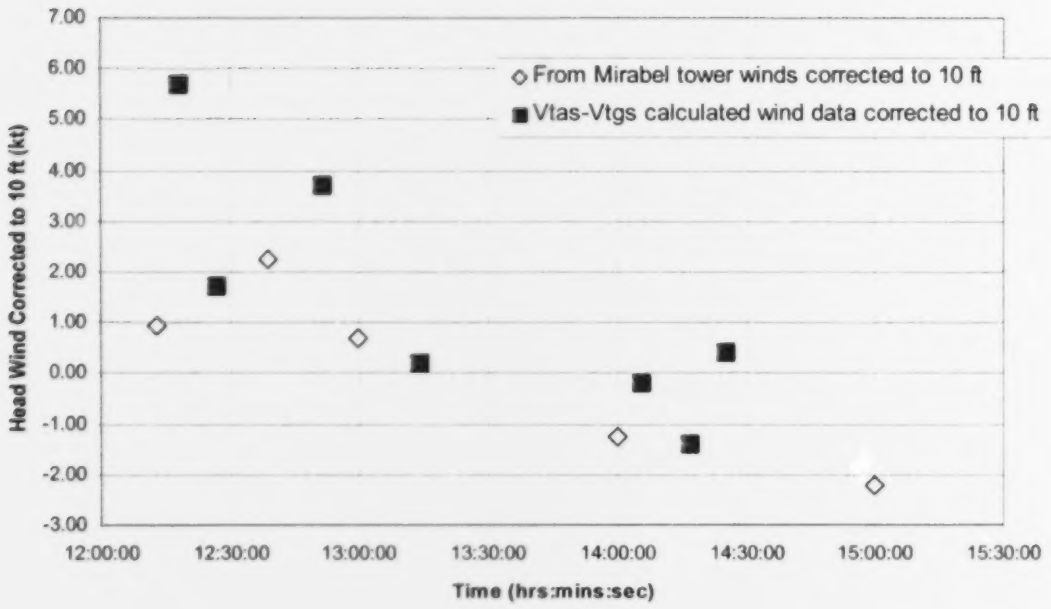


Figure 1: Wind Data Comparison

A headwind sensitivity study was performed to determine the effect that a 2 knot error in headwind would have on the braking coefficients. The results showed that for a headwind increase of 2 knots, the braking coefficient would decrease by 0.009. This shows the braking coefficients to be not very sensitive to small variations in wind speed.

3.0 TEST RESULTS

3.1 Time Histories

The time histories for each of the test points can be seen in Appendix B. Some test points were lost due to instrumentation problems, so are not included in the appendix. These lost test points include the dry runway testing performed in the morning of September 8, 2005, and two afternoon accel/stop test points conducted on runway 29. The loss of the two accel/stop points was suspected during testing and these runs were repeated.

3.2 Braking Friction Coefficient

Test results for the aircraft derived brake friction coefficients are presented in Appendix A. The relationship between brake friction coefficient and true groundspeed has been determined for each of the six braking test points. All test points show a similar characteristic with groundspeed; however, the aircraft derived wet braking friction for runway 11/29 at Mirabel was only about 50% of the braking coefficient levels of FAR 25.109 Amendment 92/JAA AMJ 25.1591.

3.3 Propeller Drag Model

The result from the brakeless accel/stop test shows the propeller drag to be in agreement with the certified propeller drag model. It is plotted along with the 2xdiscing model in Figure 2.

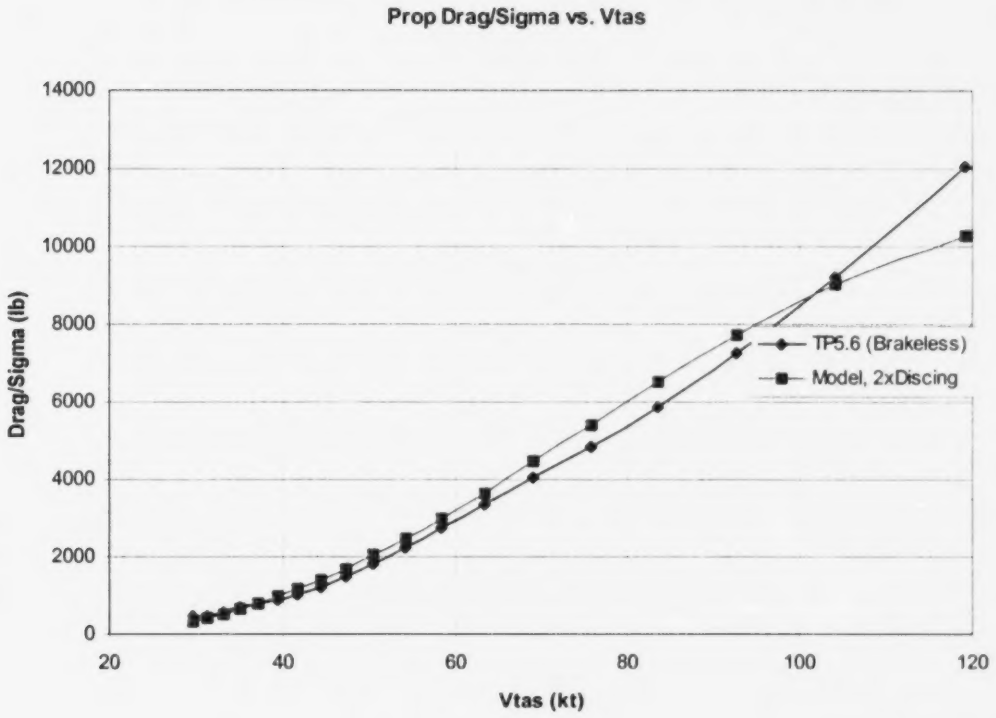


Figure 2: Propeller Drag Model Validation

This "prop drag" calculated from the brakeless test includes the combined affects of propeller forces and engine jet exhaust thrust. Variations between the model and calculated forces are due to small uncertainties in longitudinal force accounting for modeled rolling friction and aerodynamic drag as well as measurement of slope, wind and deceleration. The difference between the two curves represents the sum of these effects.

The 2xDiscing propeller drag model was used in the analysis of the braking friction coefficients found in Appendix A. Test point 5.6, the brakeless test, shows the affect of the small difference in longitudinal force seen in Figure 2 as a potential braking coefficient error.

4.0 CONCLUSION

The wet runway testing performed on runway 11/29 at Mirabel Airport found the aircraft derived braking coefficients to be lower than the braking coefficient model for a fully modulating anti-skid braking system of FAR 25.109 Amendment 92/FAA AMJ 25.1591. This is attributed to the smooth concrete surface and the condition of the runway throughout the test sections which showed heavy rubber deposits. These findings for the Dash 8 Series 400 are in line with those found during the Falcon 20 tests of Reference A on this runway.

The heavy rain present for some of the test points may have also contributed to the lower braking coefficients; however, the maximum observed water depth was measured to be no greater than 3mm to 4 mm. The poor wet surface characteristic of runway 11/29 at Mirabel was also supported by pilot comments. The flight crew noted that greater deceleration was felt before the heavy rain started; leading to not a very pronounced braking effect during the rain.

The propeller drag model was validated through a brakeless accel/stop, which supports the calculated braking coefficients. No braking system anomalies were evident in the data to suggest error in the calculated braking coefficients.

5.0 REFERENCES

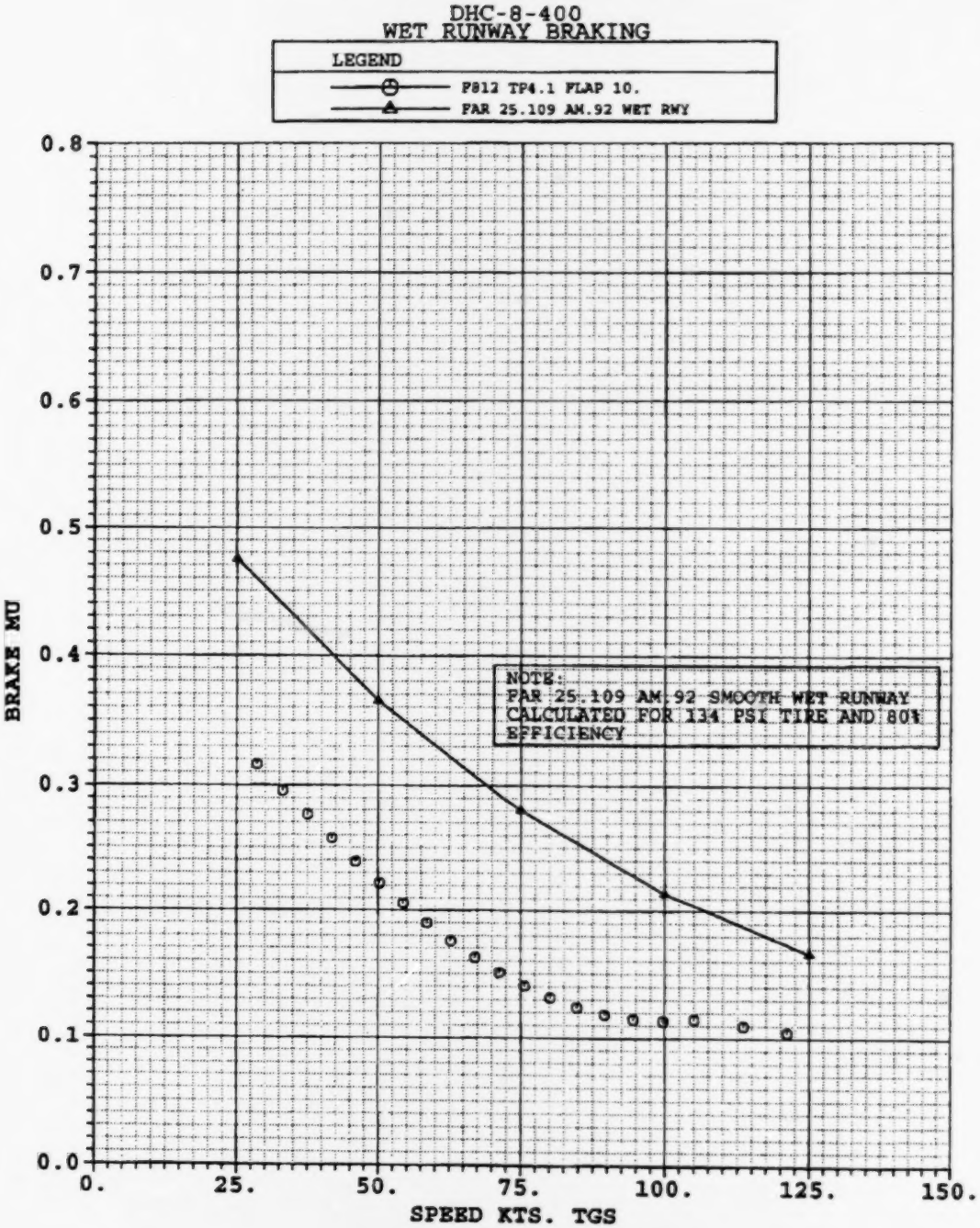
A	John B. Croll Matthew Bastian	Falcon 20 Aircraft Braking Performance On Wet Concrete Runway Surfaces, National Research Council of Canada, LTR-FR-137, July 2004
B	Mark Doogan Eric Herrmann Phil Lamont	Braking Friction Coefficient and Contamination Drag for the the Dash 8 on Winter Contaminated Runways DHC-D4547-97-09, September 1997

APPENDIX A - Aircraft Braking Friction Coefficients

All tests were performed on runway 11/29 which had a slope of -0.1% and -0.26%, respectively, over the test section.

Table A-1: Flight Test 812 Summaries (September 8, 2005)

Test Pt.	Start Time	Type	Manoeuvre	Runway	Weight (lbs.)	Pressure Altitude (ft.)	OAT (°C)	Headwind at 10' (kts.)
2	09:45:06	Brakeless	Landing	11	52170	N/A	N/A	N/A
3	09:49:07	Brakeless	Accel/Stop	11	51940	N/A	N/A	N/A
4.1	12:17:25	Max.Brake	Landing	11	51100	145.0	17.7	5.7
4.2	12:26:30	Max.Brake	Landing	11	50850	136.2	17.7	1.70
5.1	12:51:00	Max.Brake	Accel/Stop	11	50480	175.5	17.4	3.70
5.2	13:13:40	Max.Brake	Accel/Stop	29	50050	180.9	17.3	0.2
5.3	13:27:27	Max.Brake	Accel/Stop	29	49900	N/A	N/A	N/A
5.4	13:44:19	Max.Brake	Accel/Stop	29	49650	N/A	N/A	N/A
5.5	14:05:20	Max.Brake	Accel/Stop	29	49250	179.0	17.3	-0.2
5.6	14:15:50	Brakeless	Accel/Stop	29	49120	168.4	17.4	-1.4
5.7	14:24:40	Max.Brake	Accel/Stop	29	49000	182.5	17.2	0.4


DHC-8-400
WET RUNWAY BRAKING
LEGEND
P812 TP4.1 FLAP 10.
FAR 25.109 AM.92 WET RWY
NOTE:
FAR 25.109 AM.92 SMOOTH WET RUNWAY
CALCULATED FOR 134 PSI TIRE AND 80%
EFFICIENCY
BRAKE MU
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.
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75.
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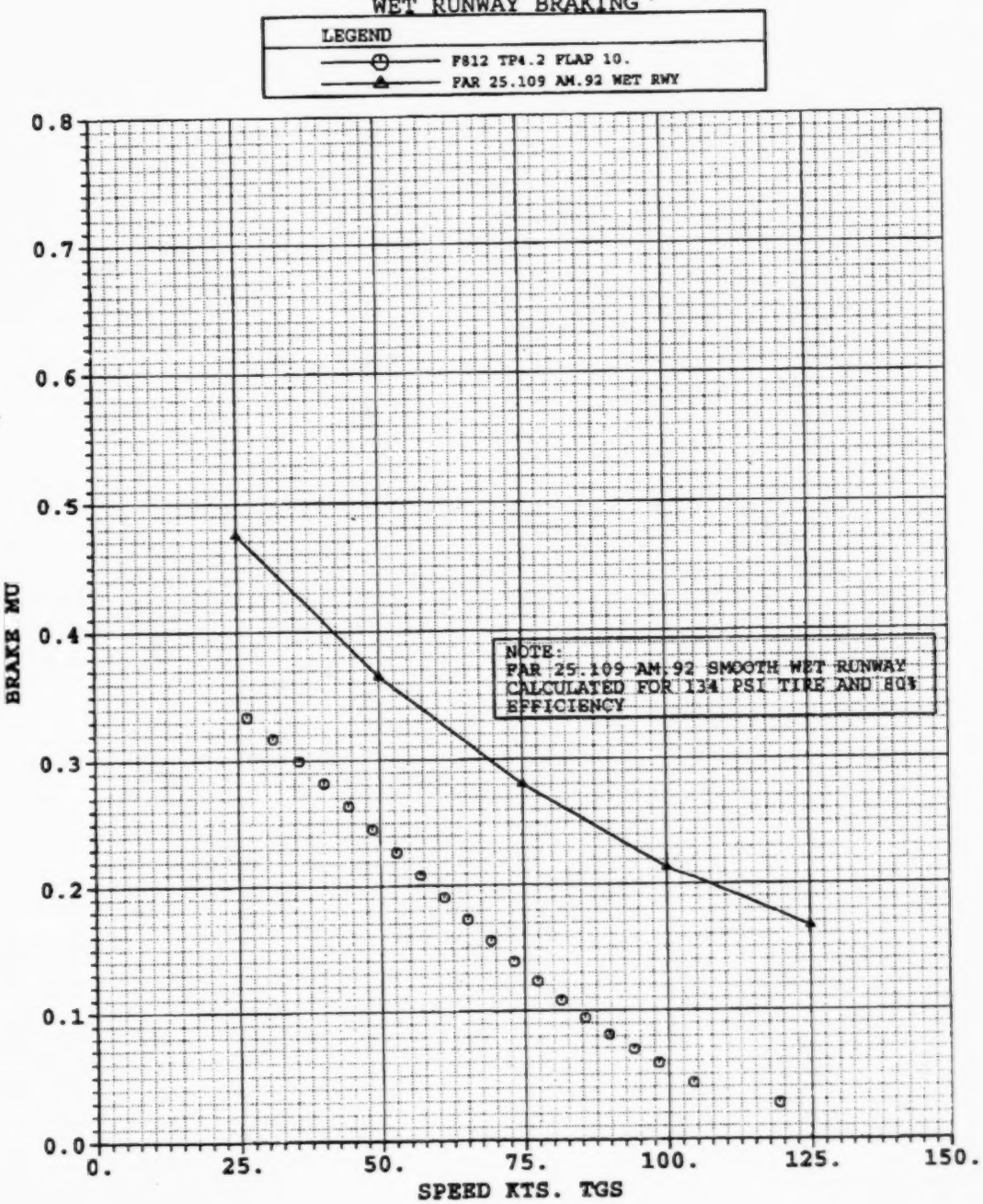
125.
150.
SPEED KTS. TGS

DHC-8-400
WET RUNWAY BRAKING



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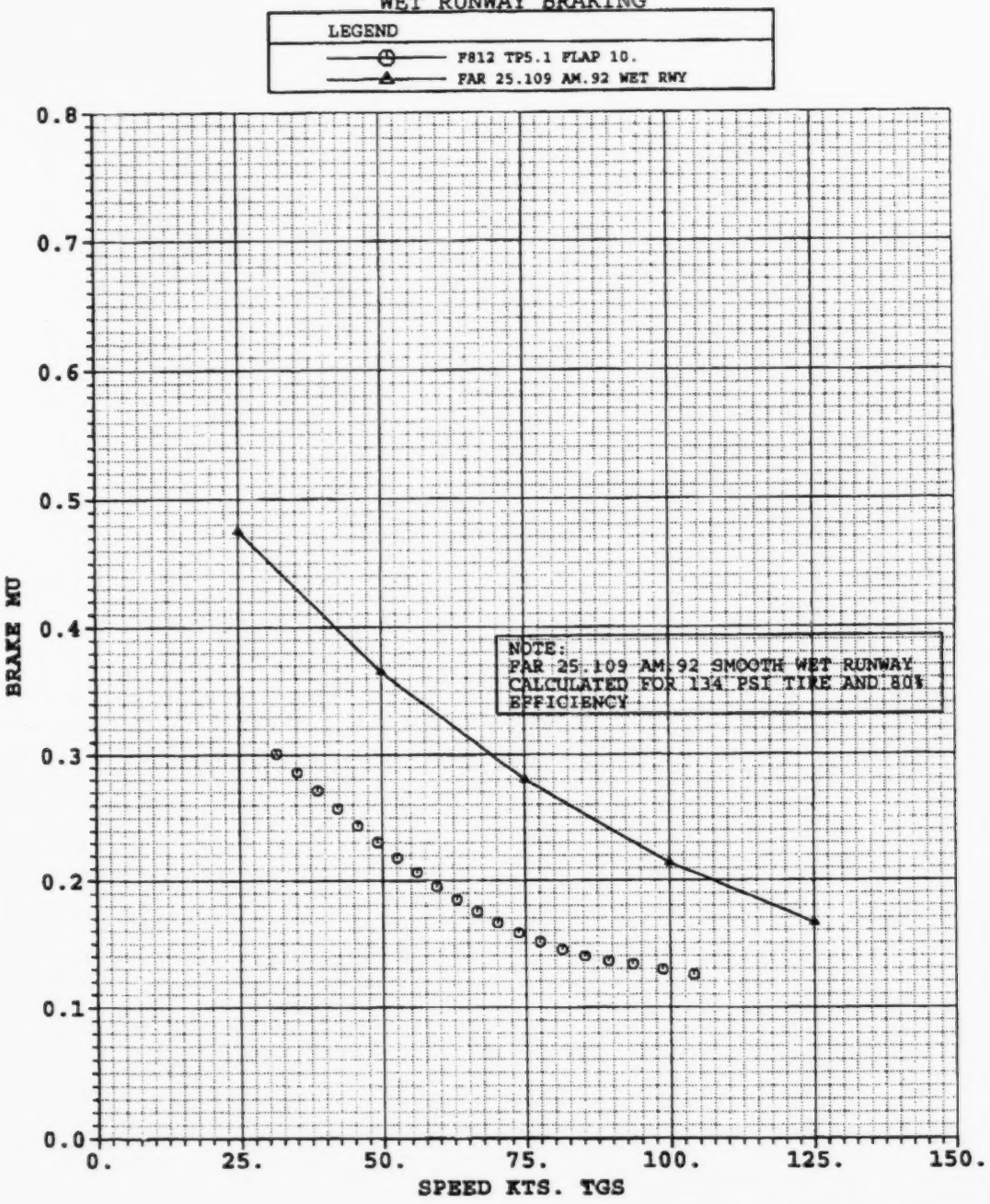

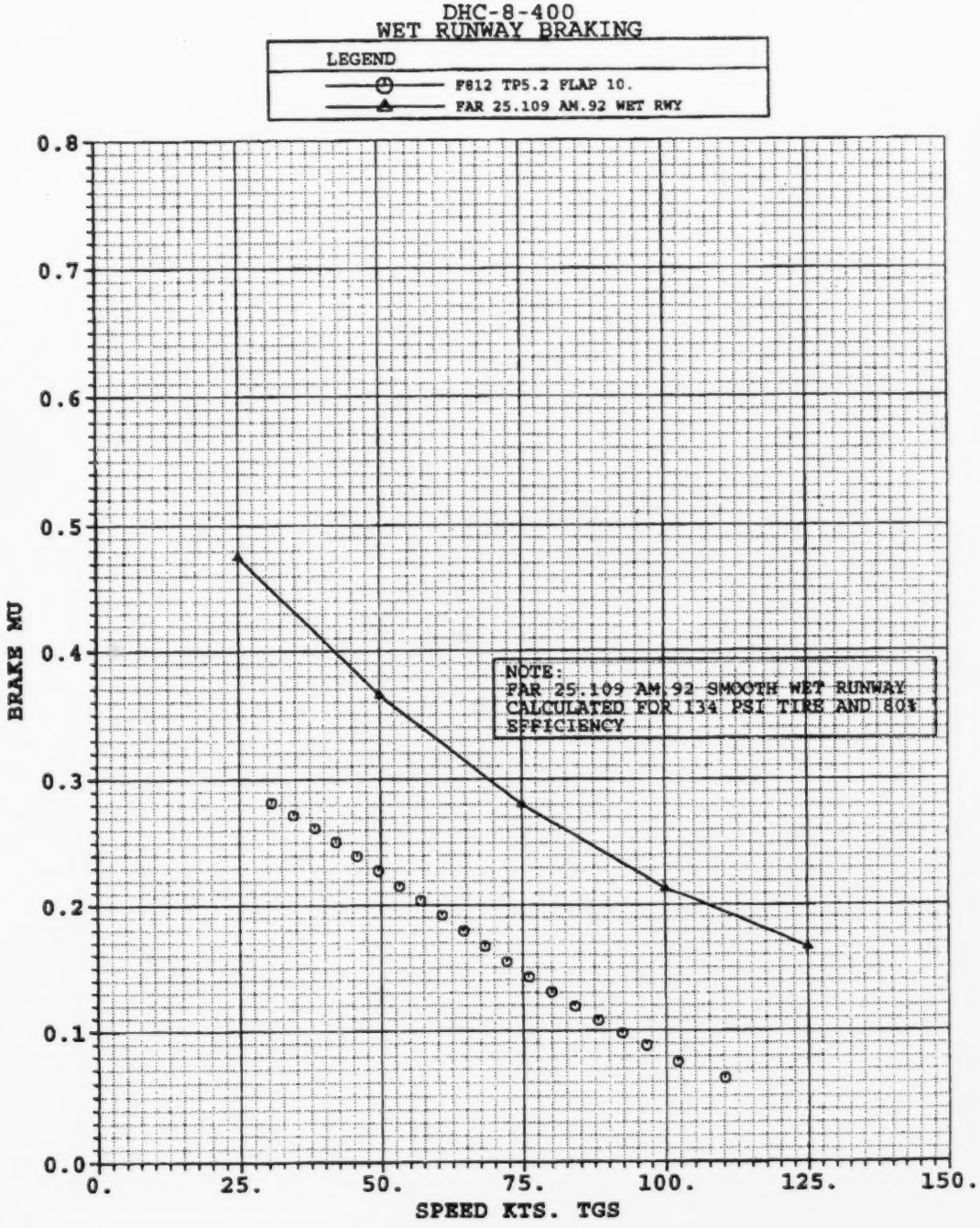
DHC-8-400
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75.
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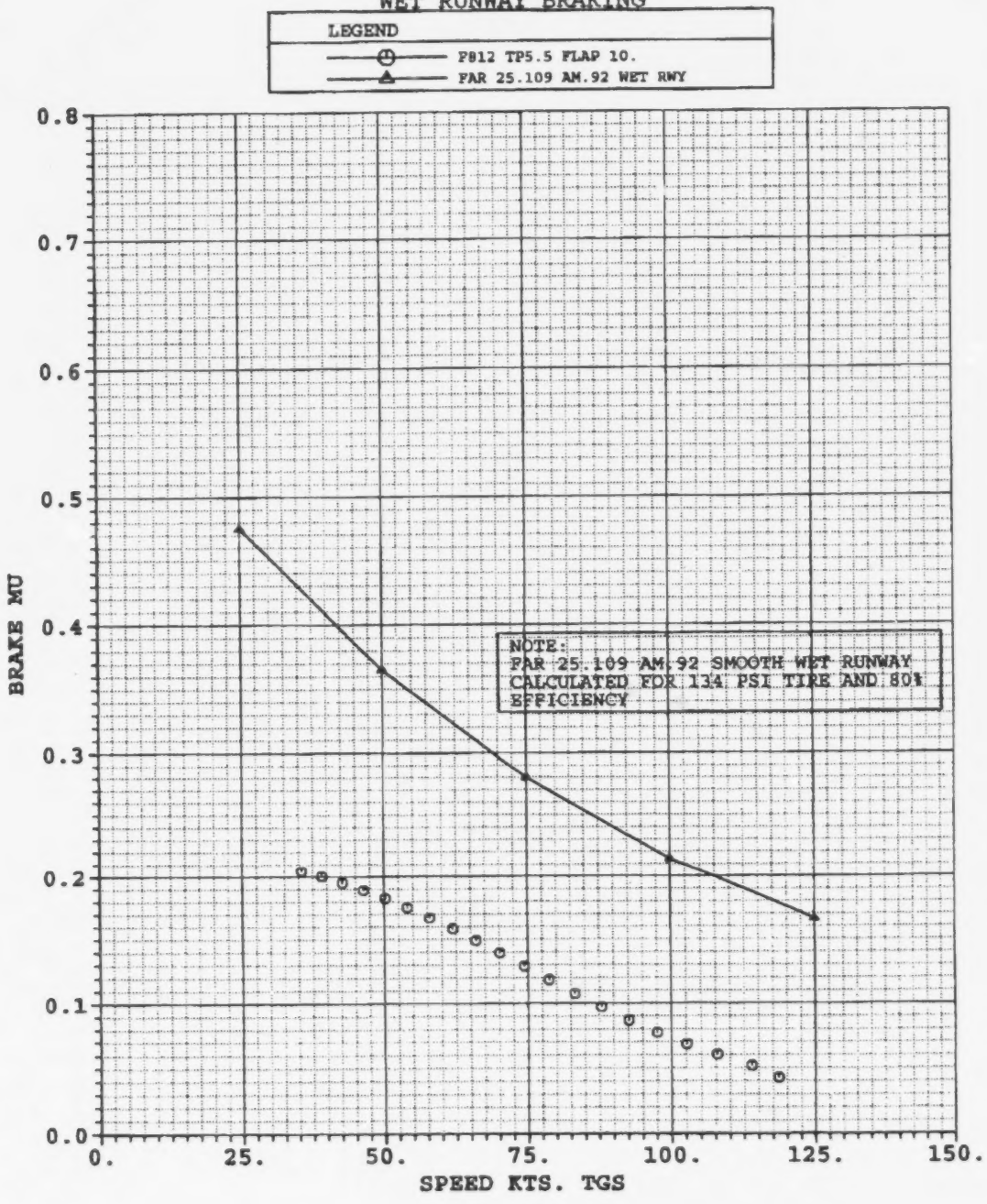
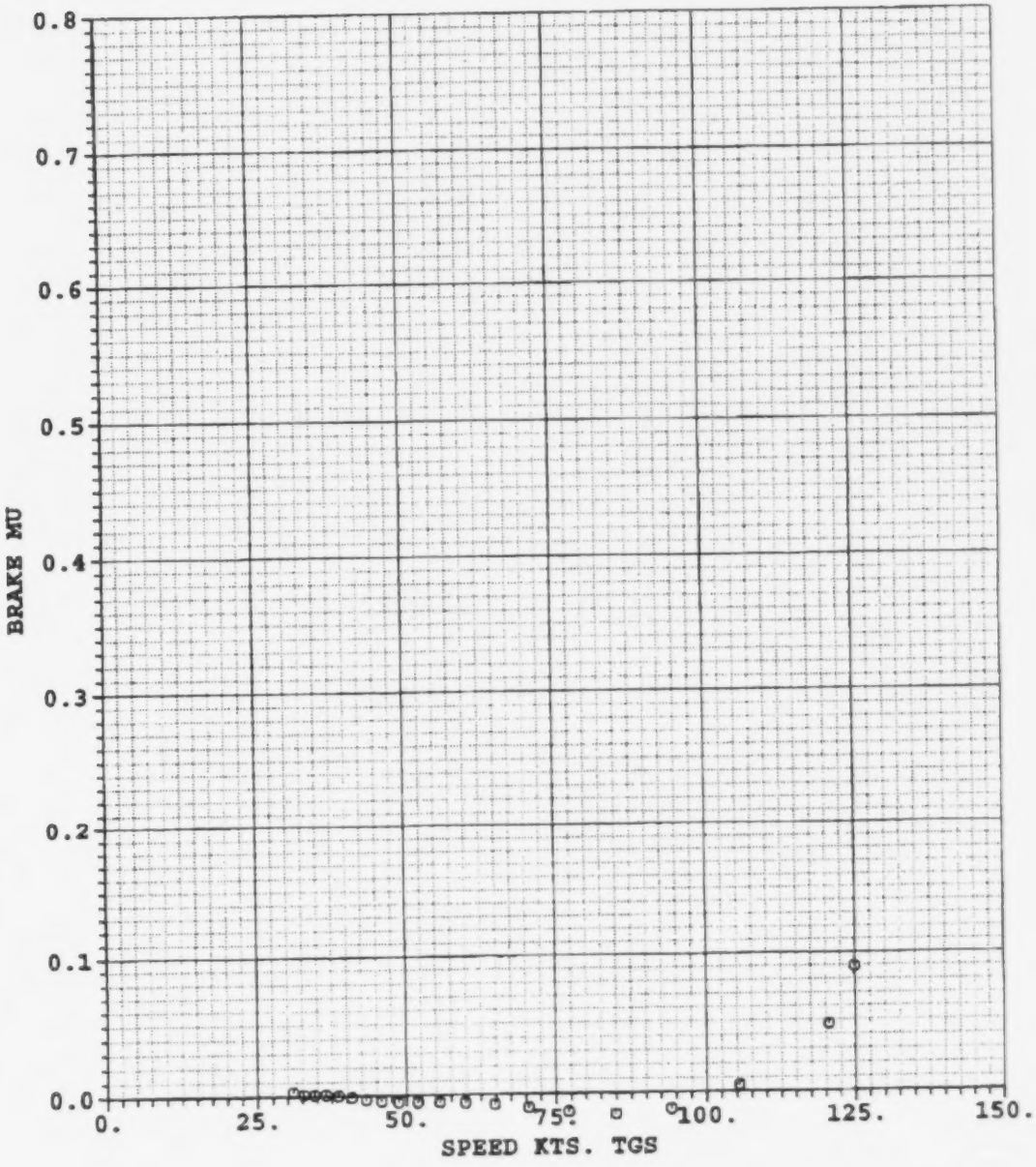
125.
150.
SPEED KTS. TGS
NOTE:
FAR 25.109 AM.92 SMOOTH WET RUNWAY
CALCULATED FOR 134 PSI TIRE AND 80%
EFFICIENCY

DHC-8-400
WET RUNWAY BRAKING

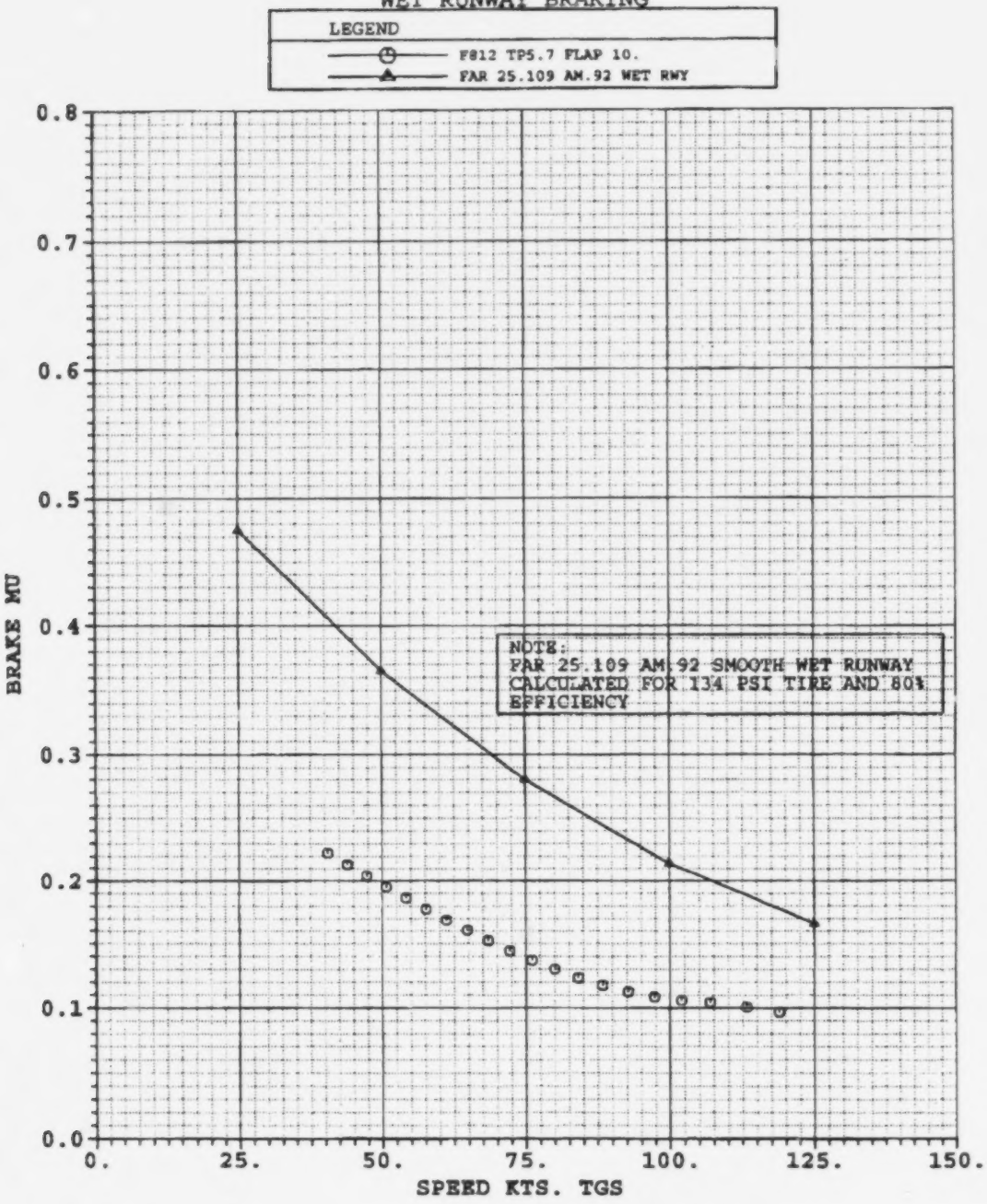


DHC-8-400
WET RUNWAY BRAKING

F812 TP5.6 (BRAKELESS)



DHC-8-400
WET RUNWAY BRAKING



APPENDIX B - Summary of Test Runs and Data Time Histories

All tests were performed on runway 11/29 which had a slope of -0.1% and -0.26%, respectively, over the test sections.

The following is a list of flight test parameters that are used in the subsequent test run summaries:

AEL	-	angle elevator left
AER	-	angle elevator right
ALTBM	-	altitude boom
ALTCP	-	altitude co-pilot
ALTP	-	altitude pilot (units are PSF not ft)
ASIFL	-	angle spoiler inboard flight left
ASIFR	-	angle spoiler inboard flight right
ASIP	-	aircraft airspeed indicator
ASOFL	-	angle spoiler outboard flight left
ASOFR	-	angle spoiler outboard flight right
Distance	-	distance of aircraft along runway centerline
IAS	-	indicated air speed based on pilot ADU
GND PROXIMITY	-	aft fuselage proximity to runway not available
GPSHGTDEV	-	GPS height standard deviation
GPSHORSPD	-	GPS horizontal ground speed
GPSLATDEV	-	GPS lateral standard deviation
GPSLONGDEV	-	GPS longitudinal standard deviation
GPSVRTSPD	-	GPS vertical speed
GPSYSUM	-	GPS lateral deviation from runway center line
MLG Drag L	-	main landing gear drag strut force (lb.) left
MLG Drag R	-	main landing gear drag strut force (lb.) right
NWIL	-	wheel speed inboard left
NWIR	-	wheel speed inboard right
NWOL	-	wheel speed outboard left
NWOR	-	wheel speed outboard right
Nx	-	aircraft acceleration parallel to longitudinal axis
Nz	-	aircraft acceleration parallel to vertical axis
PBIL	-	pressure brake inboard left
PBIR	-	pressure brake inboard right
PBOL	-	pressure brake outboard left
PBOR	-	pressure brake outboard right
PBPL	-	pilot brake pedal position left
PBPR	-	pilot brake pedal position right (peak points are above filter limits for PBP; therefore flat spots exist in traces)

Rad. Alt	-	radar altitude	
RWYPRES	-	runway pressure	l runway
RWYTEMP	-	runway temperature	l data
RWYWDDIR	-	runway wind direction	l corrupted
RWYWDSPD	-	runway wind speed	l
TBIL	-	temp brake inboard left	
TBIR	-	temp brake inboard right	
TBOL	-	temp brake outboard left	
TBOR	-	temp brake outboard right	
Theta	-	aircraft pitch	
WOW	-	weight off wheels	

Table B-1: Flight Test Summaries (September 8, 2005)

Test Pt.	Type	Manoeuvre	Runway	Weight (lbs.)	Pressure Altitude (ft.)	OAT (°C)	Headwind at 10' (kts.)
4.1	Max.Brake	Landing	11	51100	145.0	17.7	5.7
4.2	Max.Brake	Landing	11	50850	136.2	17.7	1.70
5.1	Max.Brake	Accel/Stop	11	50480	175.5	17.4	3.70
5.2	Max.Brake	Accel/Stop	29	50050	180.9	17.3	0.2
5.5	Max.Brake	Accel/Stop	29	49250	179.0	17.3	-0.2
5.6	Brakeless	Accel/Stop	29	49120	168.4	17.4	-1.4
5.7	Max.Brake	Accel/Stop	29	49000	182.5	17.2	0.4

The test events have been indicated on the data time histories that follow. The event names are standard markers used by the plotting program and are not necessarily literal events.

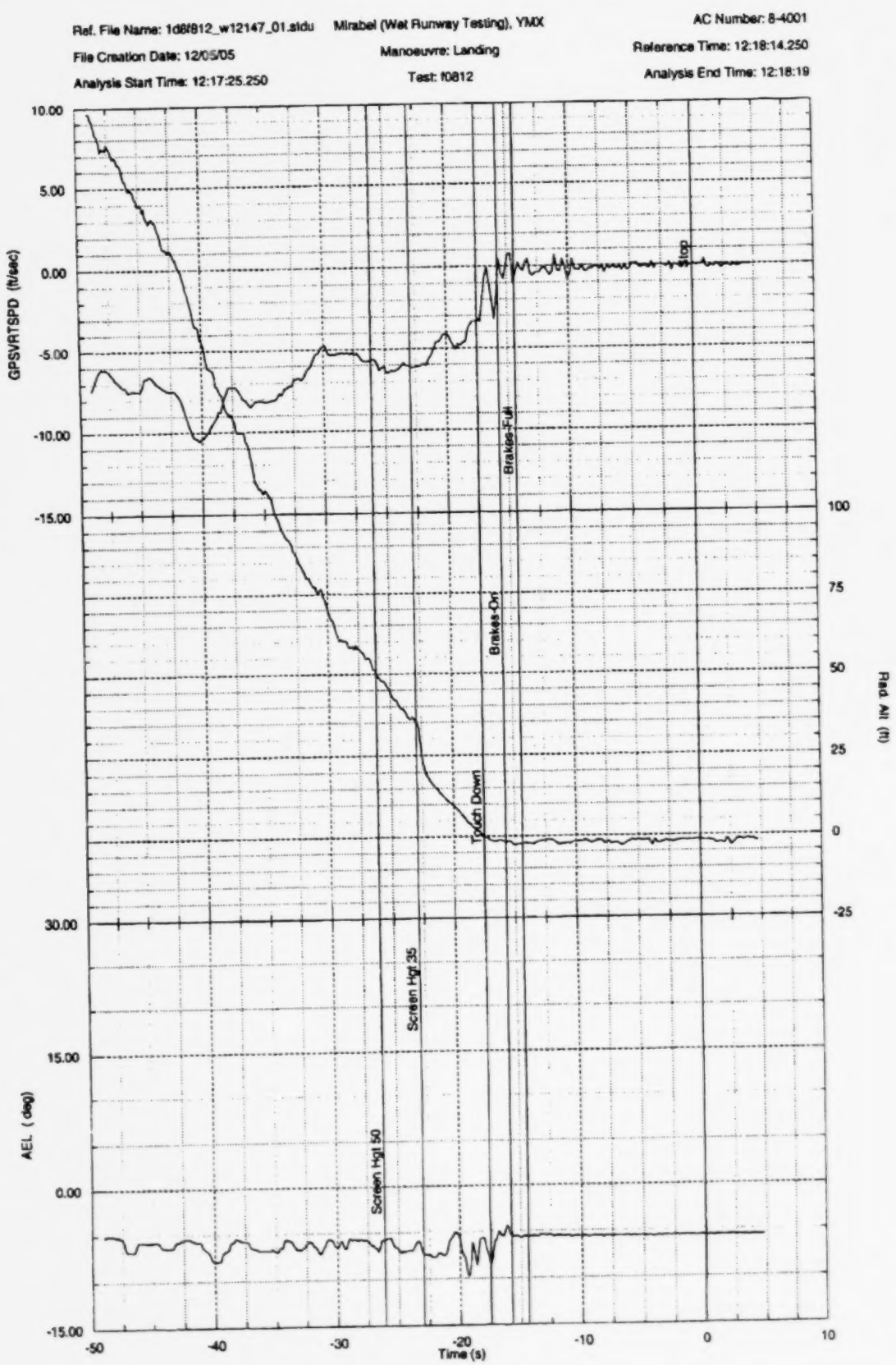
For the max brake landings, the event markers are Screen Hgt 50, Screen Hgt 35, Touch Down, Brakes On, Brakes Full and Stop. For both the max braking and brakeless accel-stops, the event markers are Brakes Off, Full Power, Brakes On, Brakes Full and Stop.

The data between the "Brakes Full" marker and the "Stop" marker represents the data used in determining the braking coefficients for all the max braking tests and the brakeless test. For the max braking tests, the "Brakes Full" marker was put at the achievement of maximum braking force, while for the brakeless tests the "Brakes Full" marker was put at the achievement of props discing. The analysis does not start until props discing has been fully achieved. For all the test points the aircraft left the test section with some speed, and did not come to a complete stop. For the braking tests, the "Stop" marker was put at the termination of the test, which was at the point where the brakes were no longer being applied. For the brakeless test the "Stop" marker was put at the termination of the test, which was at the point of brake application.

The "Brakes On" marker is a literal meaning for the max braking tests, but not for the brakeless test. For the max braking tests, the "Brakes On" marker was put at the application of the brake, while for the brakeless test, the 'Brakes On" marker was put at the start of discing selection.

The event markers Screen Hgt 50, Screen Hgt 35, Touch Down and Brakes Off are literal meanings, however, Full Power is not. The "Full Power" marker is a redundant marker for this analysis and does not represent any event; however, the marker is required by the plotting program and cannot be deleted.

Test Point 4.1



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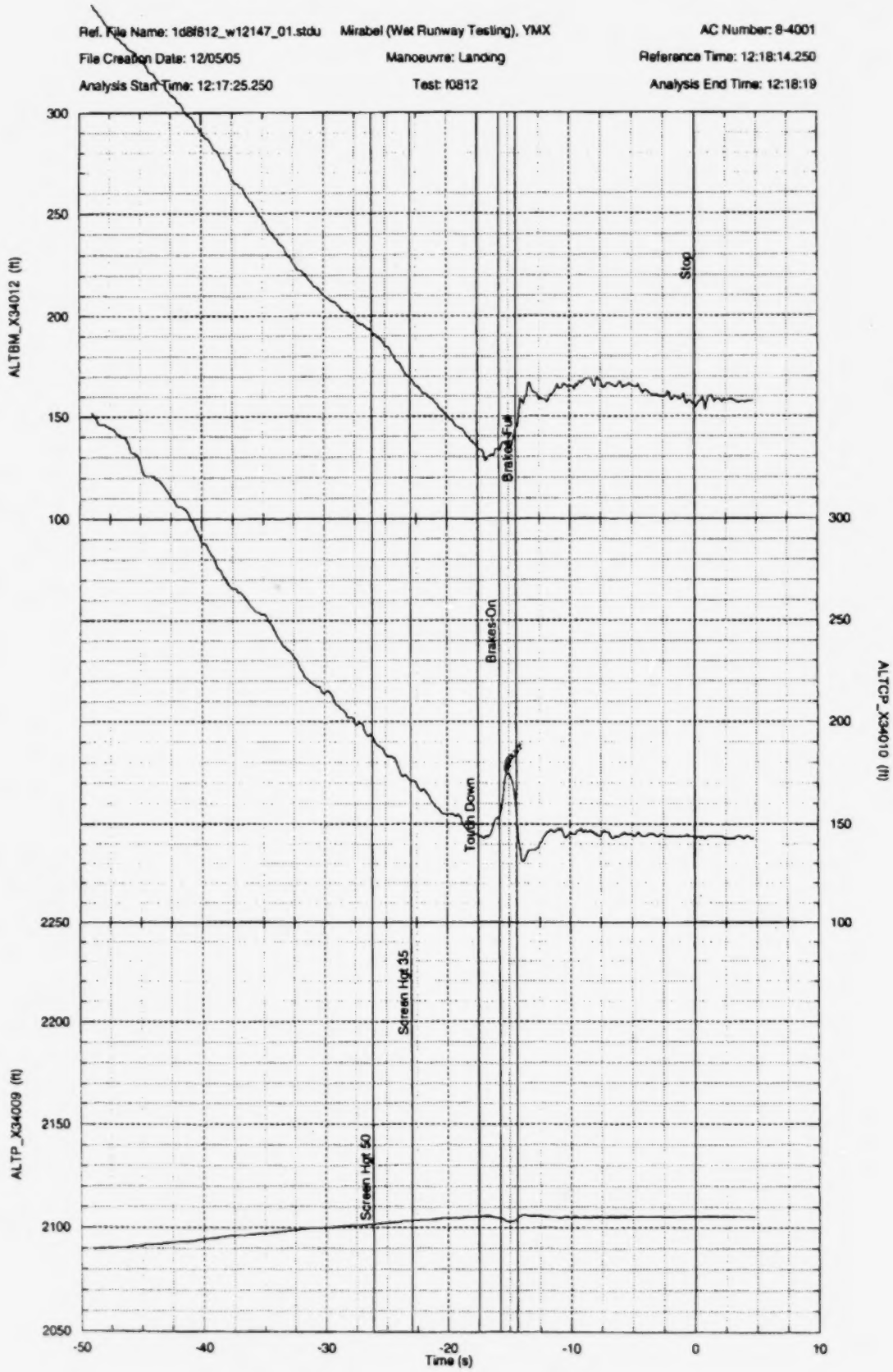

DAFT version: 2.10

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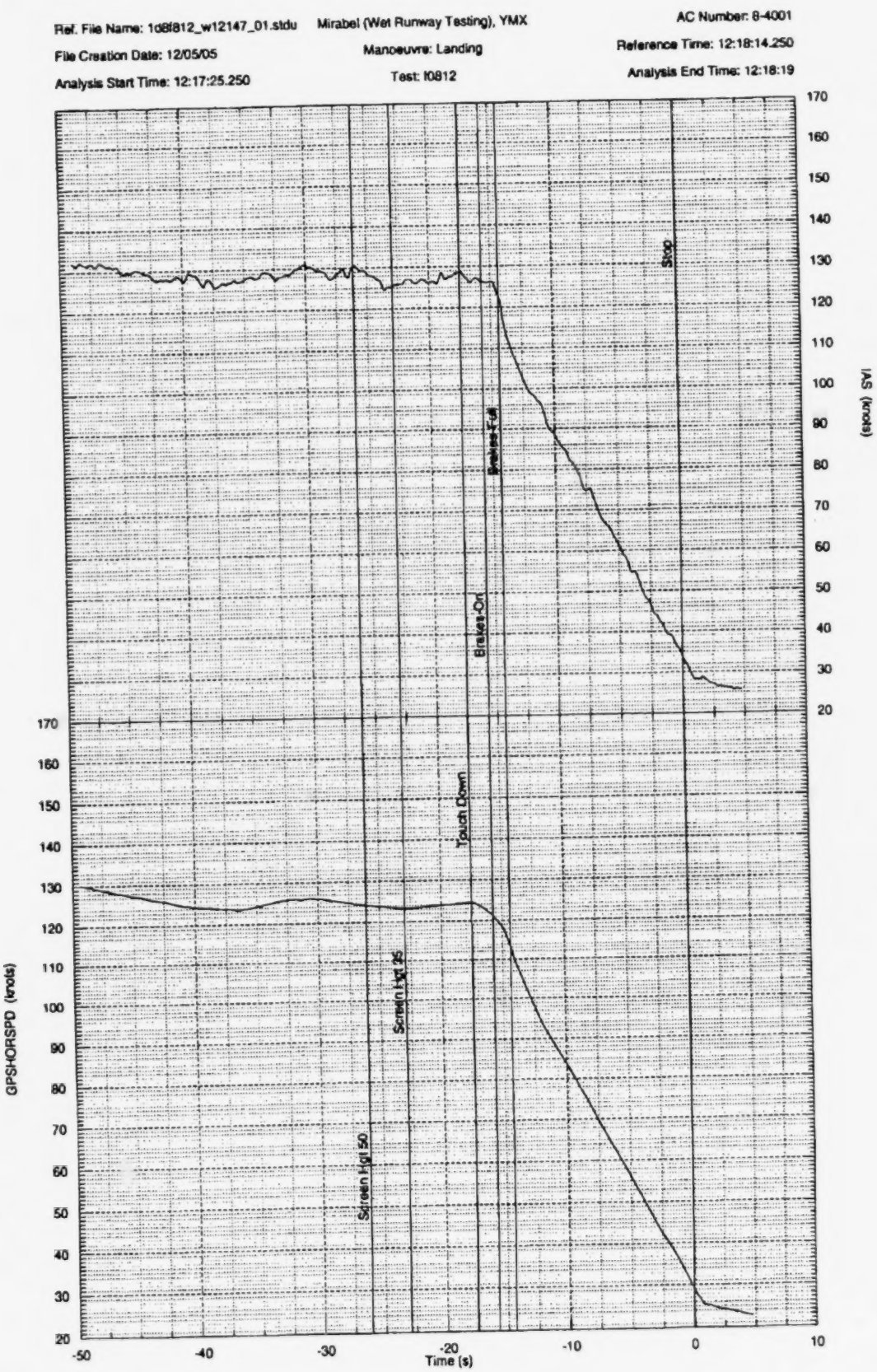
Ref. File Name: 1d8f812_w12147_01.stdu
File Creation Date: 12/05/05
Analysis Start Time: 12:17:25.250

Mirabel (Wet Runway Testing), YMX
Manoeuvre: Landing
Test: f0812

AC Number: 8-4001
Reference Time: 12:18:14.250
Analysis End Time: 12:18:19



DAFT version: 2.10

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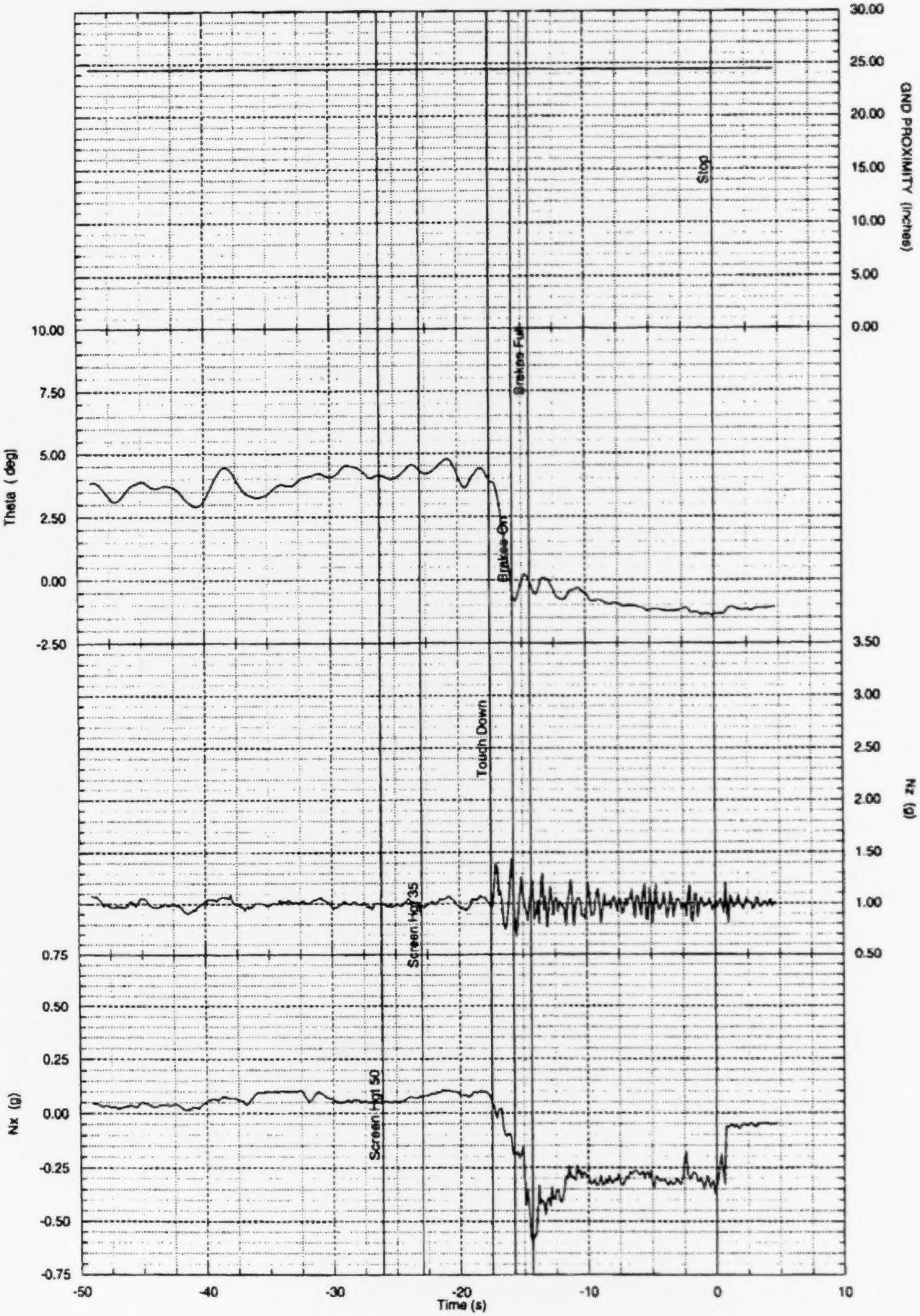
Ref. File Name: 1d8f812_w12147_01.stdu Mirabel (Wet Runway Testing), YMX AC Number: 8-4001

File Creation Date: 12/05/05 Manoeuvre: Landing Reference Time: 12:18:14.250

Analysis Start Time: 12:17:25.250 Test: f0812 Analysis End Time: 12:18:19



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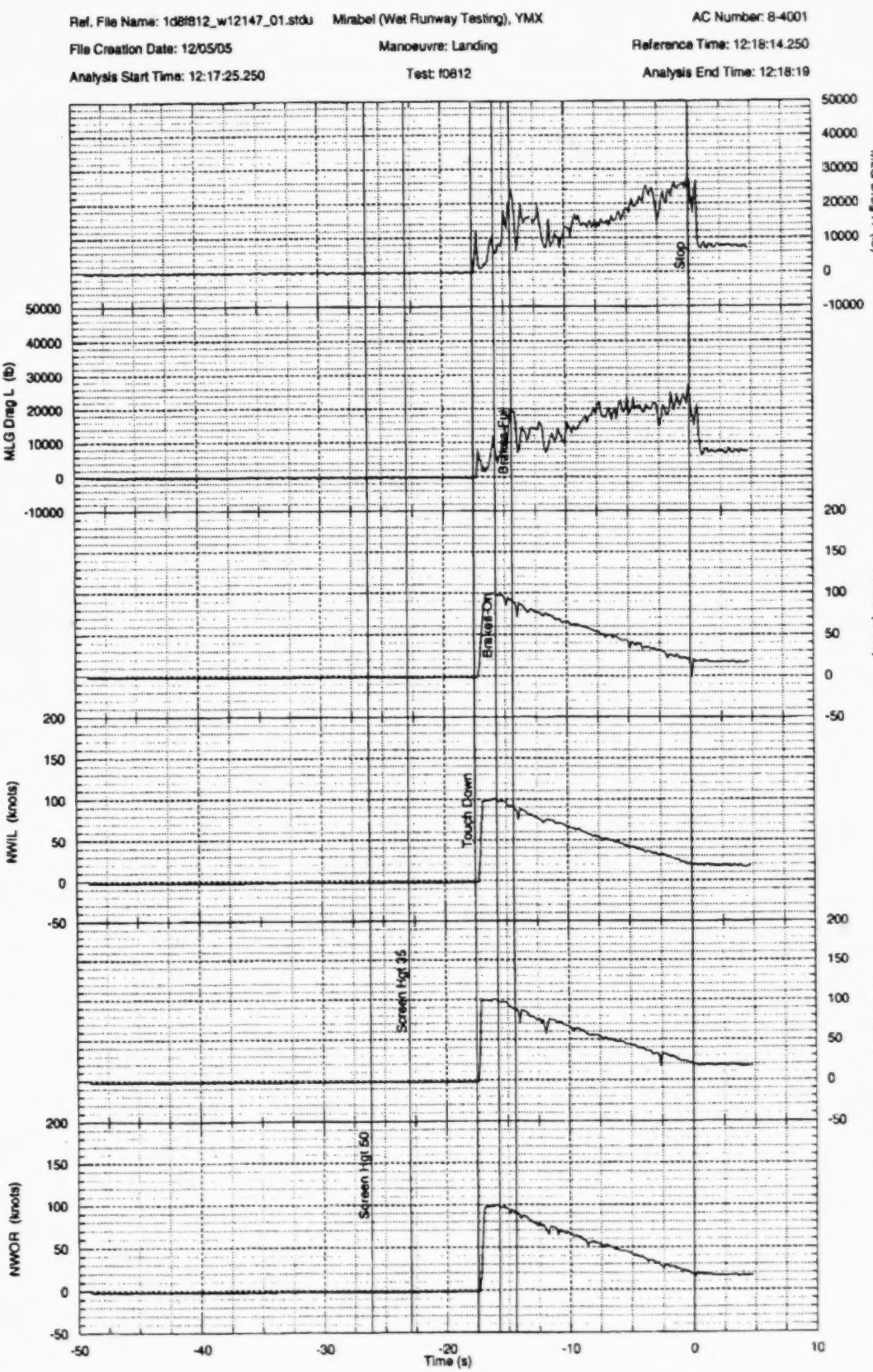
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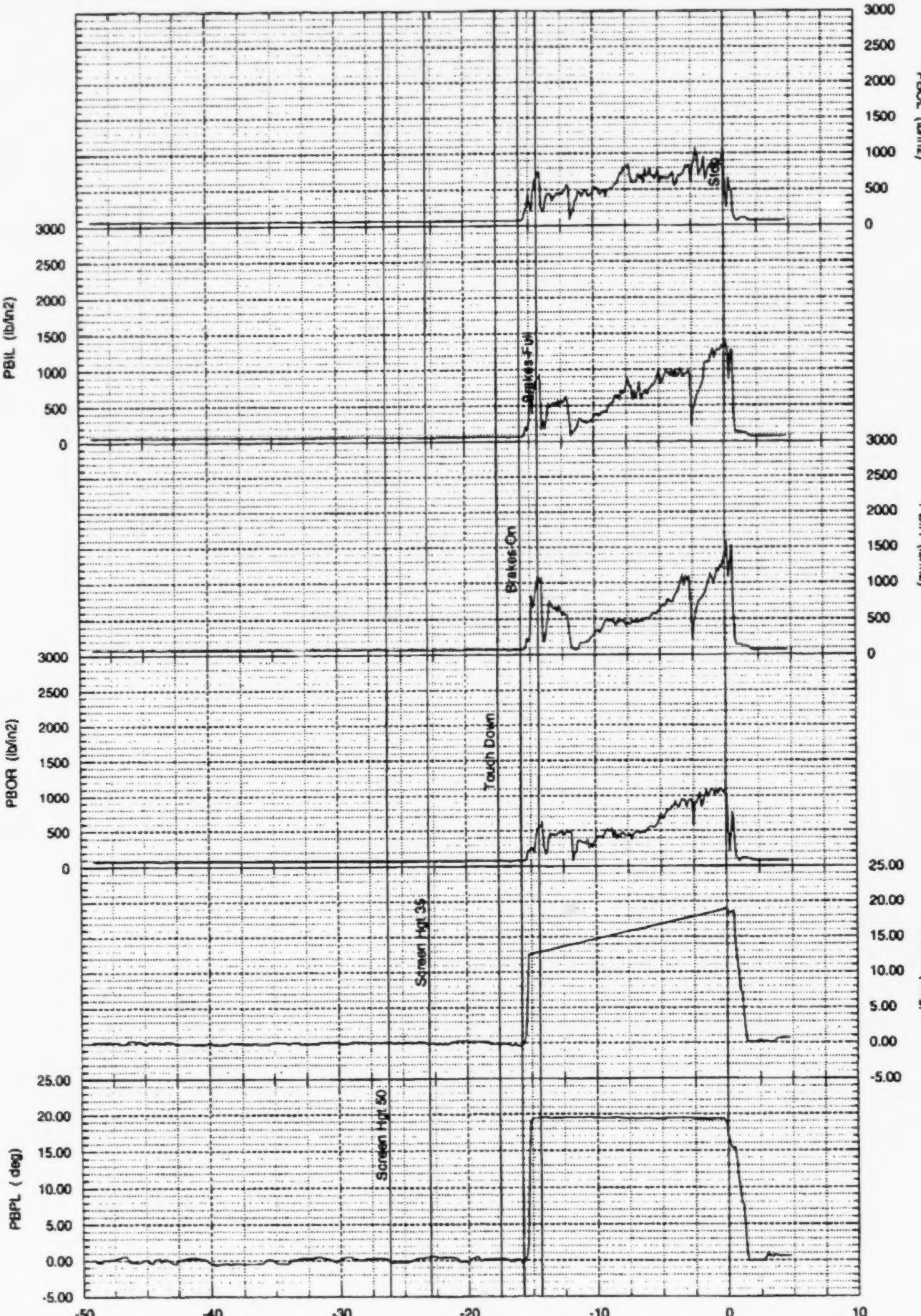
Mirabel (Wet Runway Testing), YMX
AC Number: 8-4001
File Creation Date: 12/05/05
Manoeuvre: Landing
Reference Time: 12:18:14.250
Analysis Start Time: 12:17:25.250
Test: f0812
Analysis End Time: 12:18:19
MLG Drag L (lb)
MLG Drag R (lb)
NWOL (knots)
NWIL (knots)
NWIR (knots)
NWOR (knots)
Time (s)
Stop
Brakes Full
Brakes On
Touch Down
Screen Hgt 35
Screen Hgt 50

Ref. File Name: 1d8f812_w12147_01.stdu Mirabel (Wet Runway Testing), YMX AC Number: 8-4001

File Creation Date: 12/05/05 Manoeuvre: Landing Reference Time: 12:18:14.250

Analysis Start Time: 12:17:25.250 Test: f0812 Analysis End Time: 12:18:19



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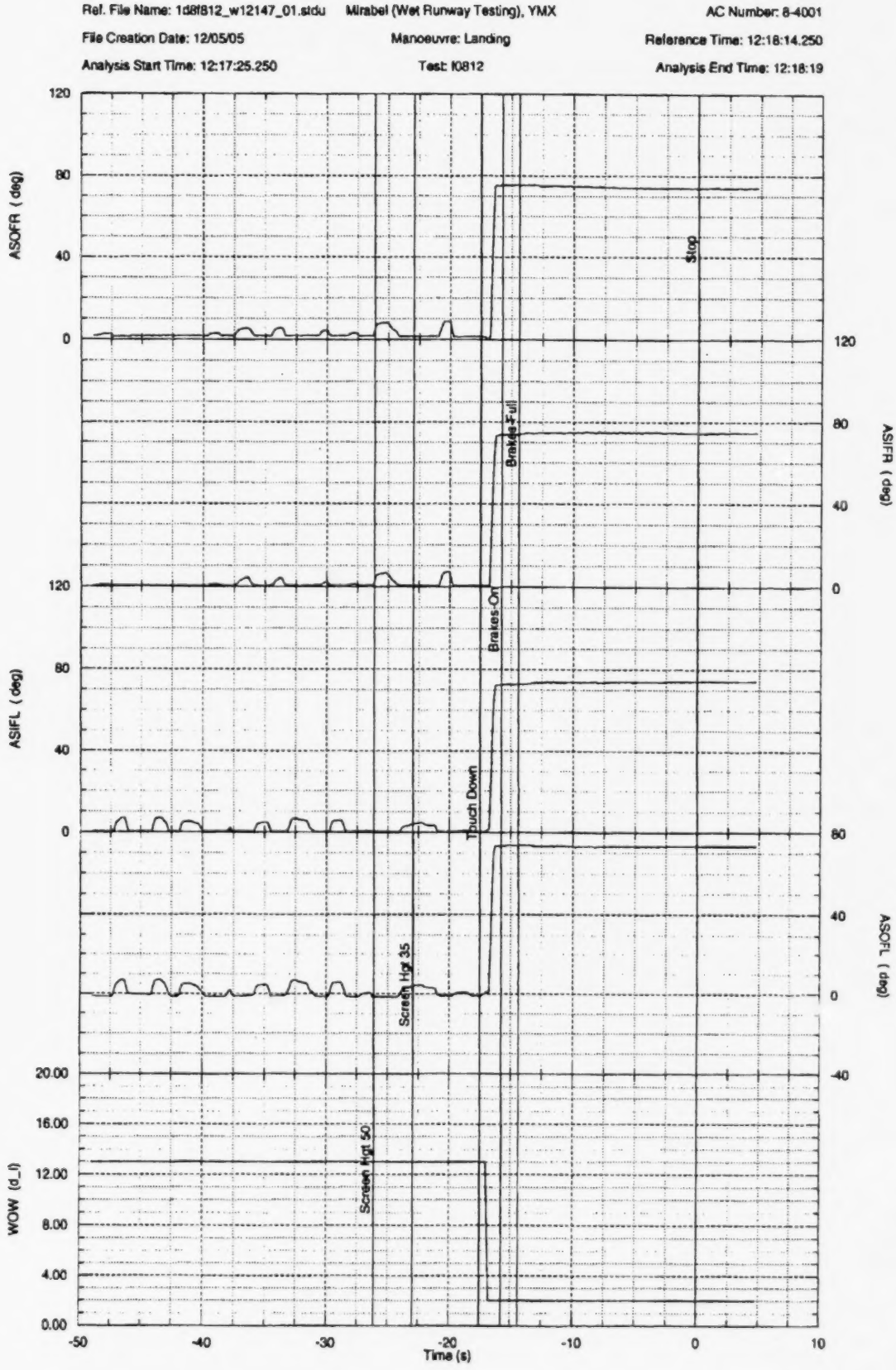
File Creation Date: 12/05/05 | Manoeuvre: Landing | Reference Time: 12:18:14.250

Analysis Start Time: 12:17:25.250 | Test: f0812 | Analysis End Time: 12:18:19



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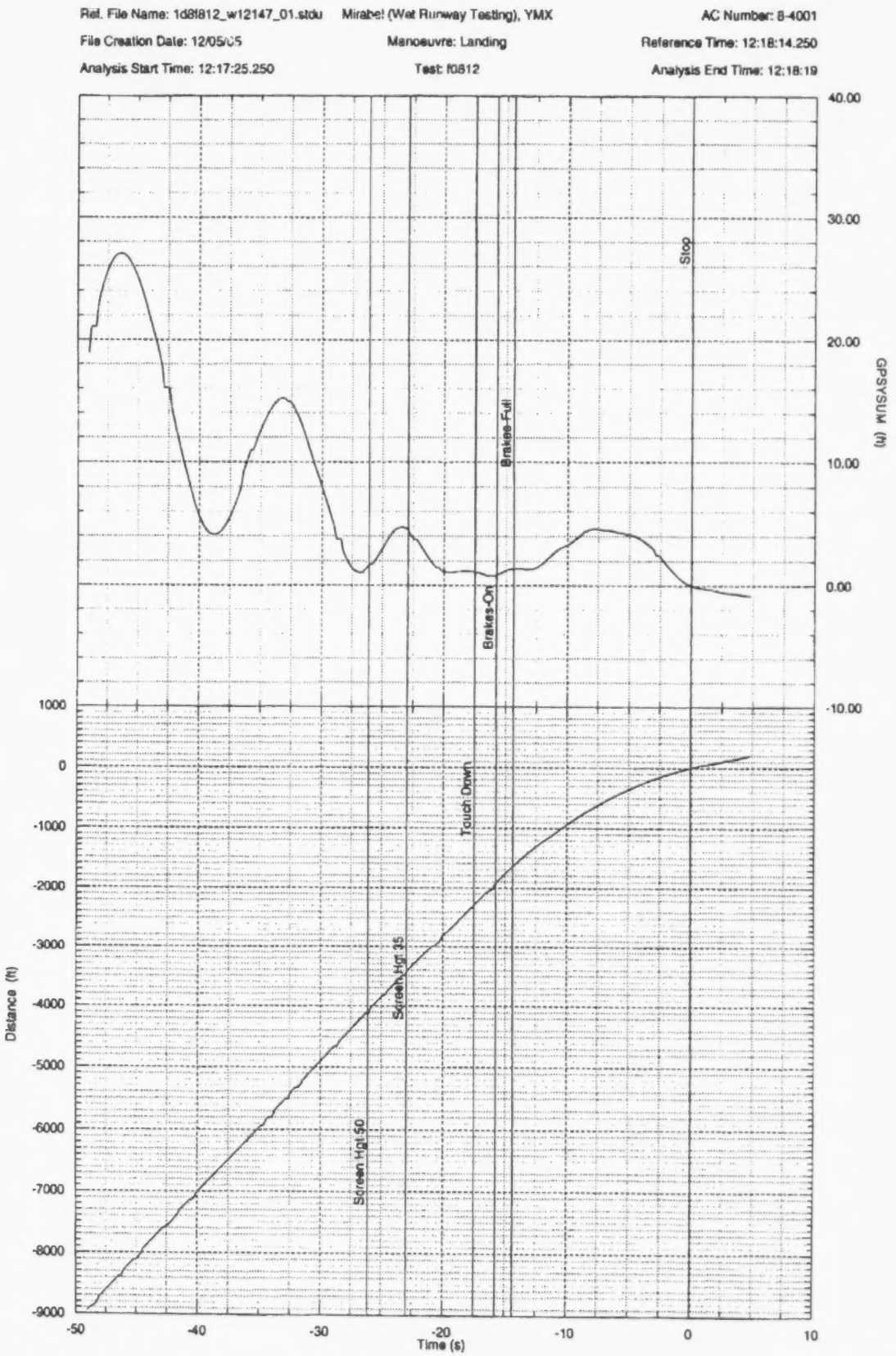

DAFT version: 2.10

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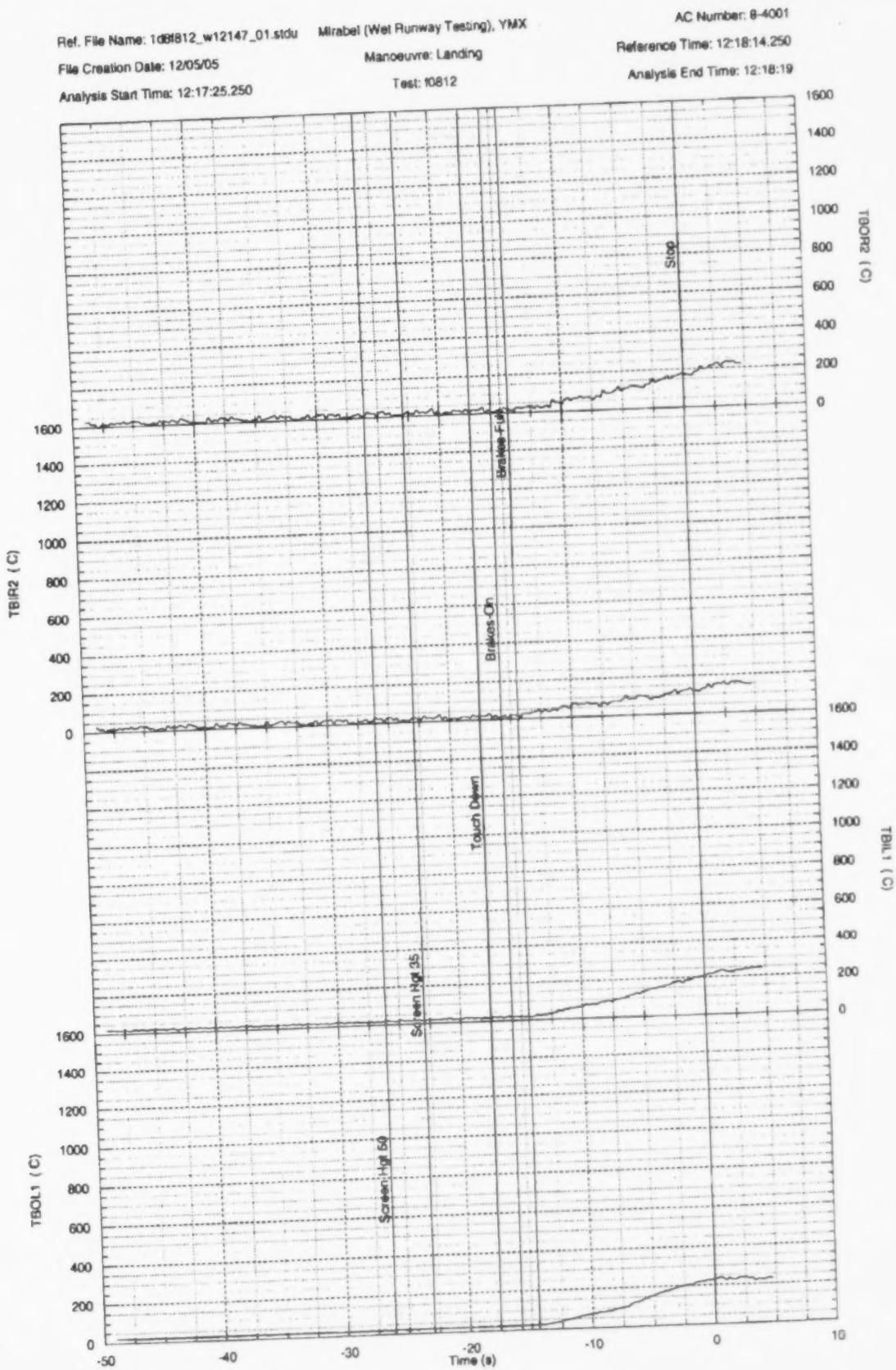
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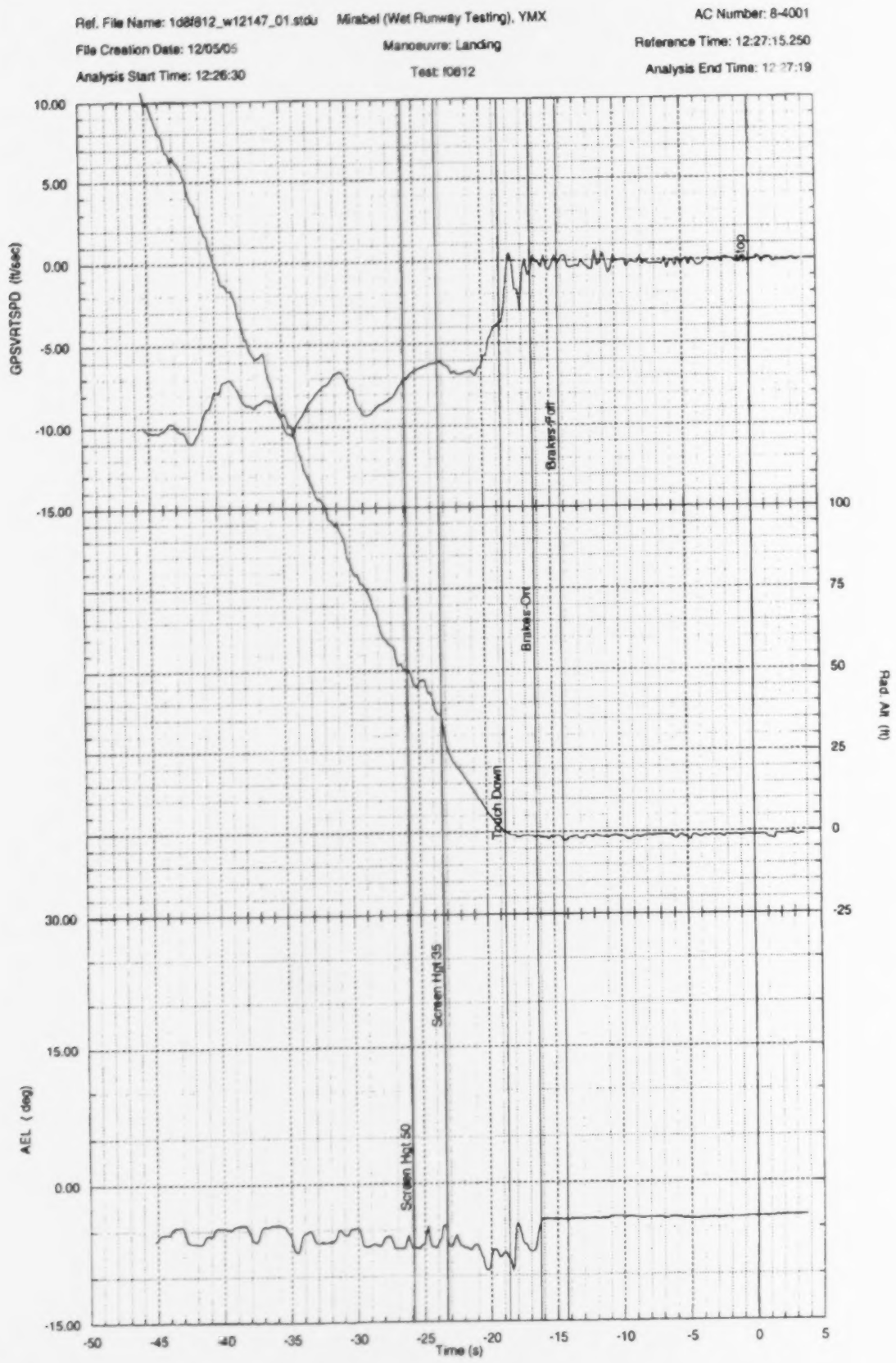
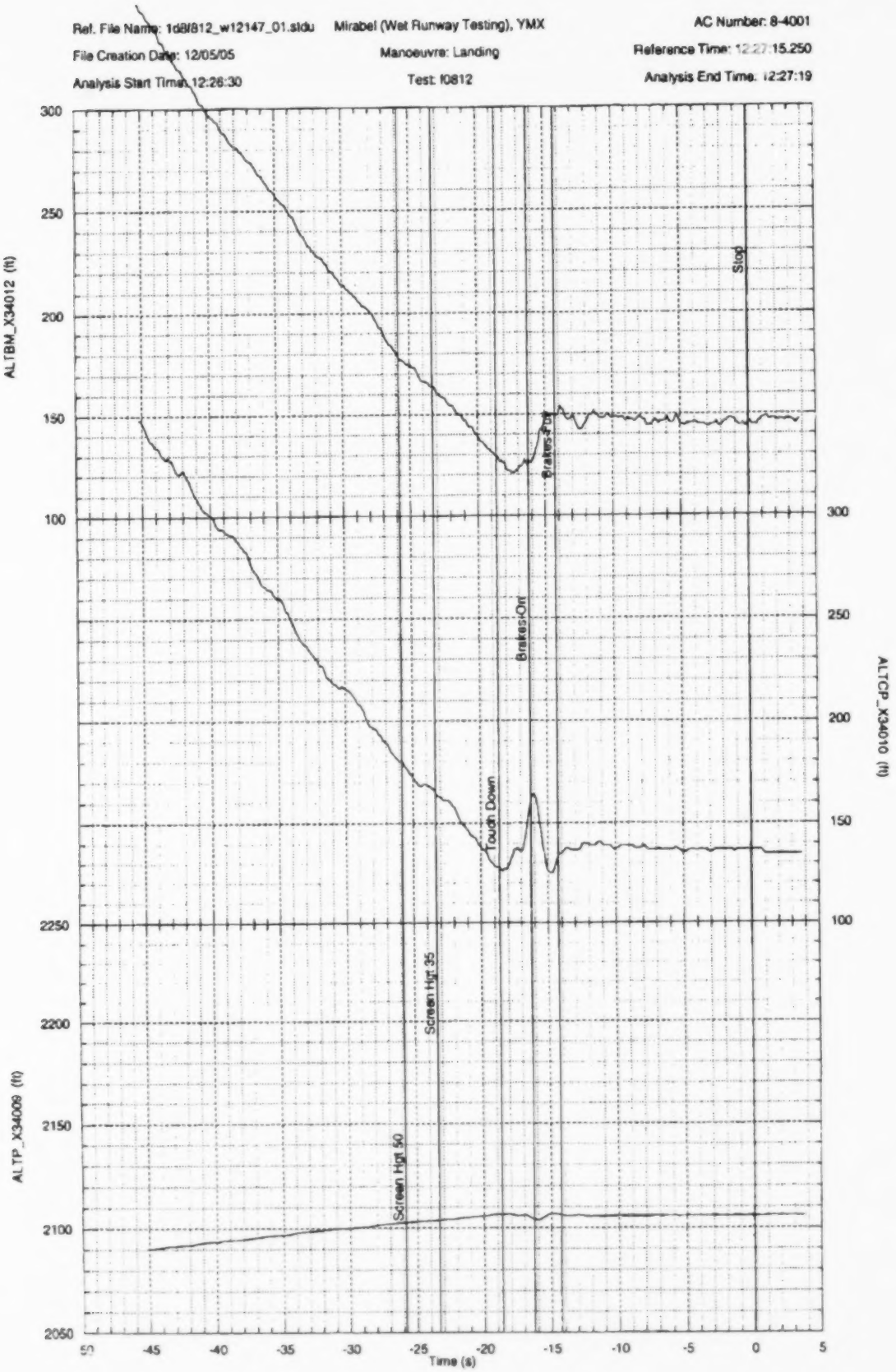
Analysis Start Time: 12:17:25.250
Mirabel (Wet Runway Testing), YMX
Manoeuvre: Landing
Test: 10812
AC Number: 8-4001
Reference Time: 12:18:14.250
Analysis End Time: 12:18:19
TBOR2 (C)
TBIR2 (C)
TBIL1 (C)
TBOL1 (C)
Stop
Brakes Full
Brakes On
Touch Down
Screen Hgt 35
Screen Hgt 50
Time (s)
-50
-40
-30
-20
-10
0
10

Test Point 4.2


Ref. File Name: 1d8f812_w12147_01.stdu
File Creation Date: 12/05/05
Analysis Start Time: 12:26:30
Mirabel (Wet Runway Testing), YMX
Manoeuvre: Landing
Test: f0812
AC Number: 8-4001
Reference Time: 12:27:15.250
Analysis End Time: 12:27:19
GPSVRTSPD (ft/sec)
10.00
5.00
0.00
-5.00
-10.00
-15.00
Stop
Brakes-Off
Brakes-On
Touch Down
Rad. Alt (ft)
100
75
50
25
0
-25
AEL (deg)
30.00
15.00
0.00
-15.00
Screen Hgt 35
Screen Hgt 50
-50
-45
-40
-35
-30
-25
-20
-15
-10
-5
0
5
Time (s)



DAFT version: 2.10

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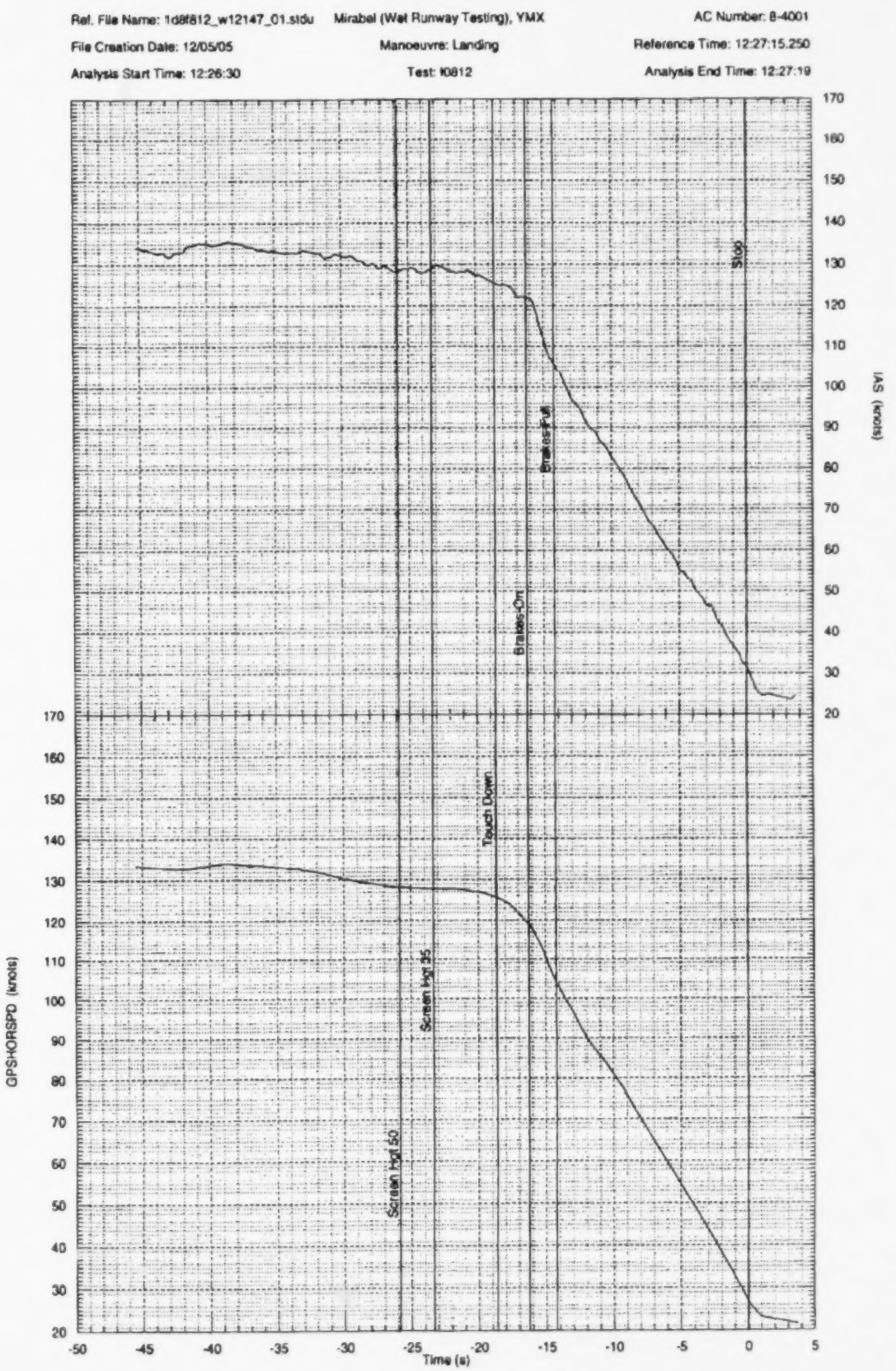
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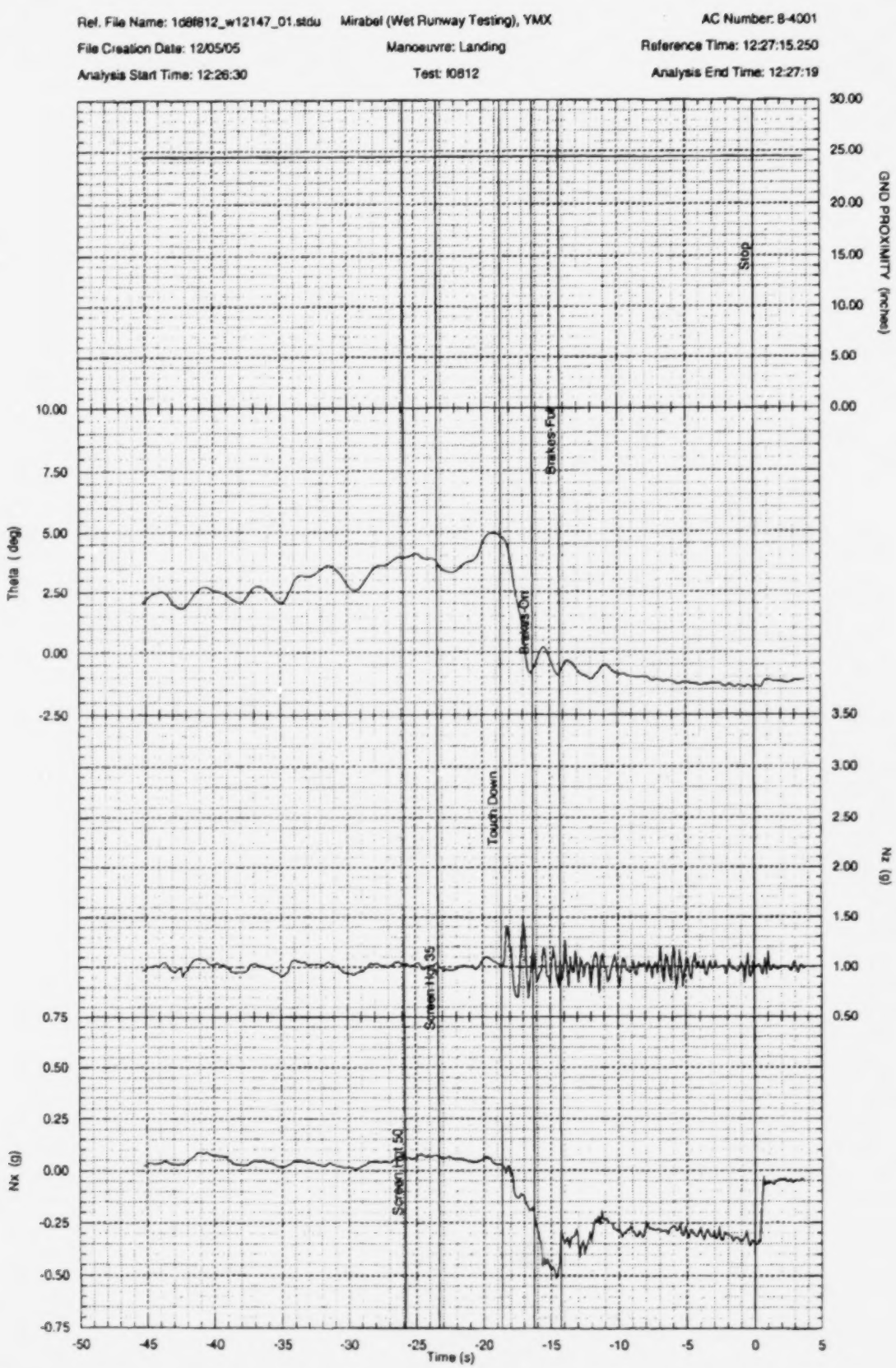
Mirabel (Wet Runway Testing), YMX
AC Number: B-4001
File Creation Date: 12/05/05
Manoeuvre: Landing
Reference Time: 12:27:15.250
Analysis Start Time: 12:26:30
Test: I0812
Analysis End Time: 12:27:19
Stop
Brakes Full
Brakes On
Touch Down
Screen Hgt 35
Screen Hgt 50
GPSHORSPD (knots)
IAS (knots)
Time (s)

Ref. File Name: 1d8f812_w12147_01.stdu | Mirabel (Wet Runway Testing), YMX | AC Number: 8-4001

File Creation Date: 12/05/05 | Manoeuvre: Landing | Reference Time: 12:27:15.250

Analysis Start Time: 12:26:30 | Test: f0812 | Analysis End Time: 12:27:19



DAFT version: 2.10

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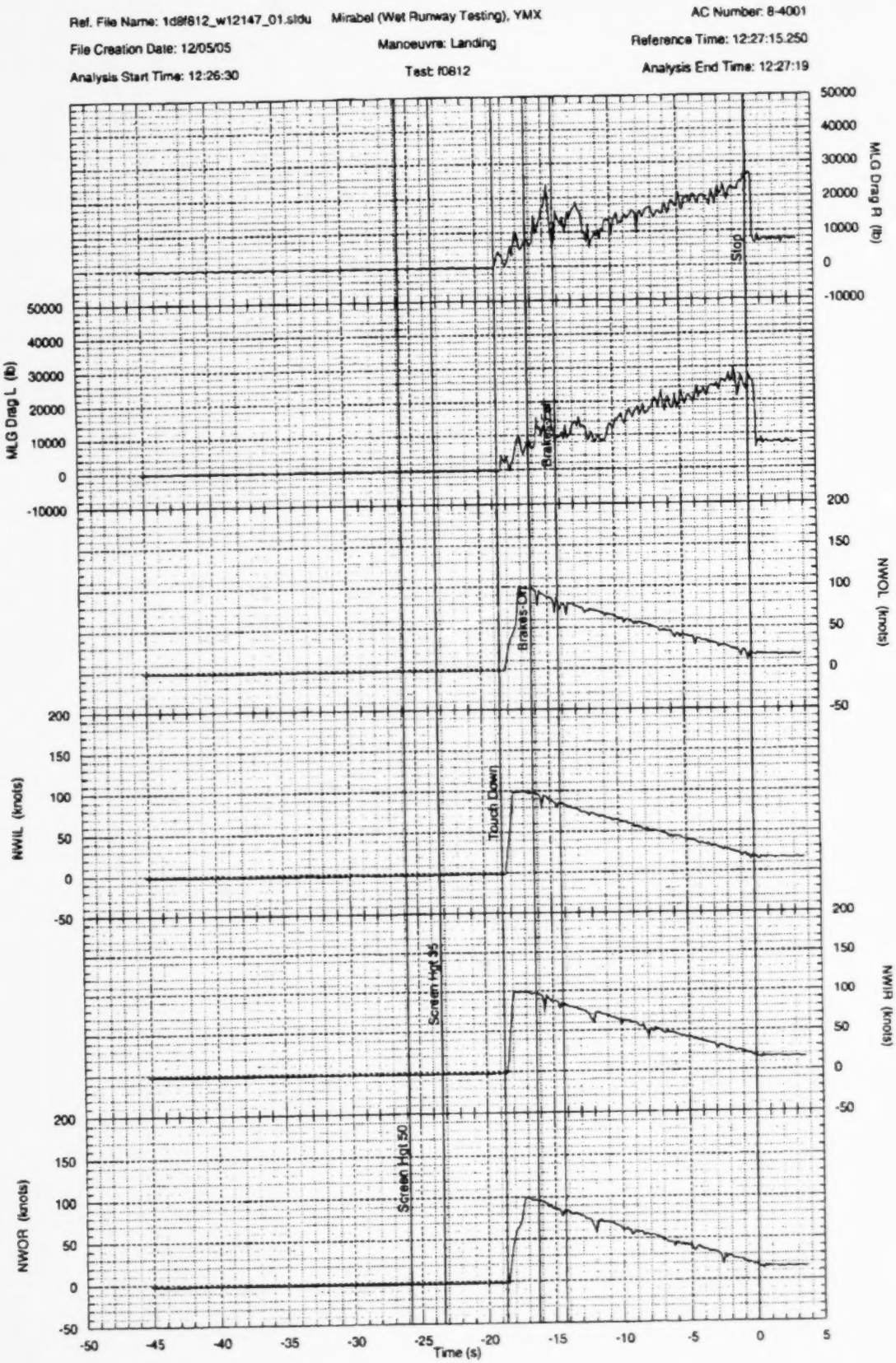

DAFT version: 2.10

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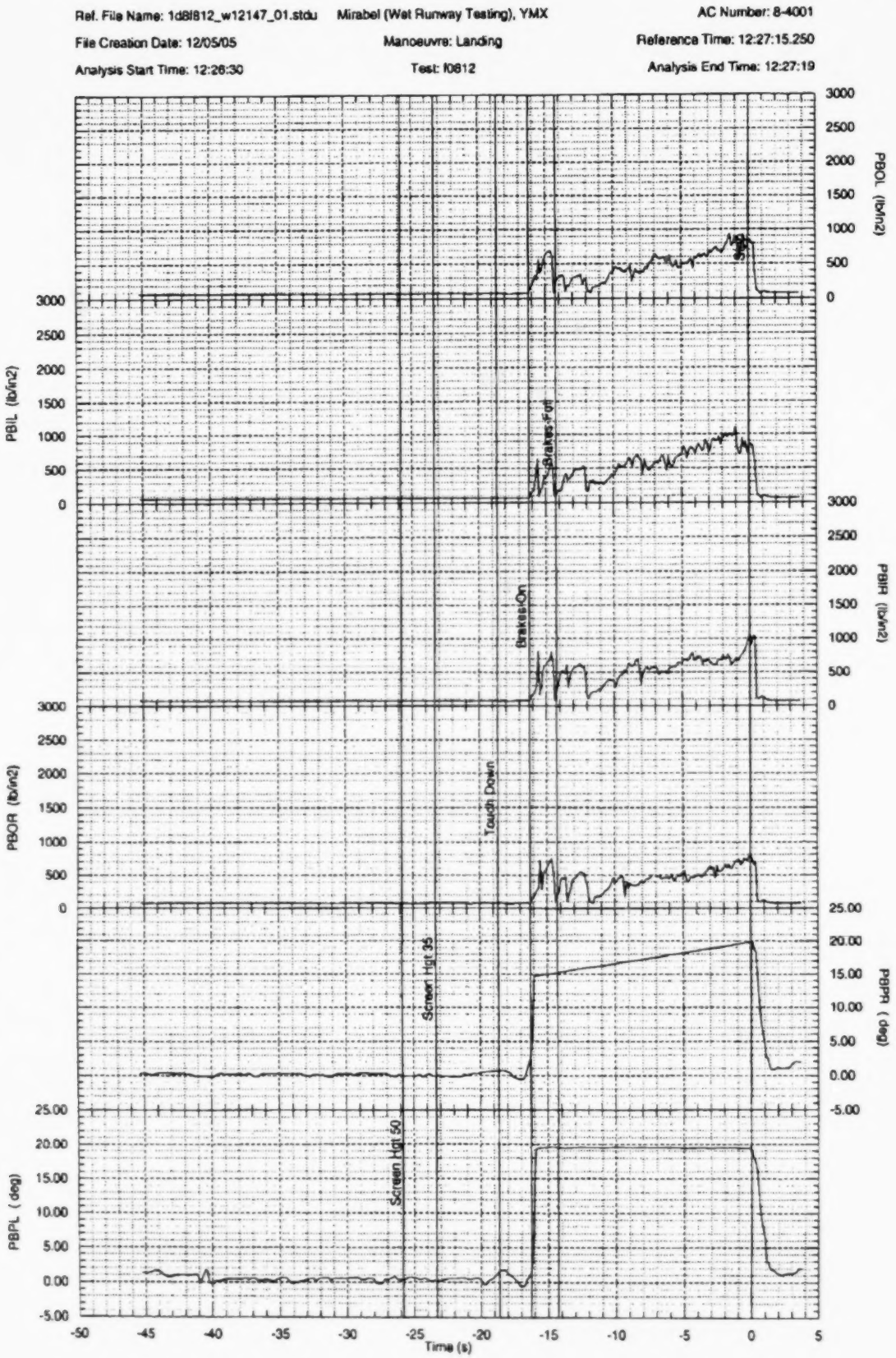

DAFT version: 2.10
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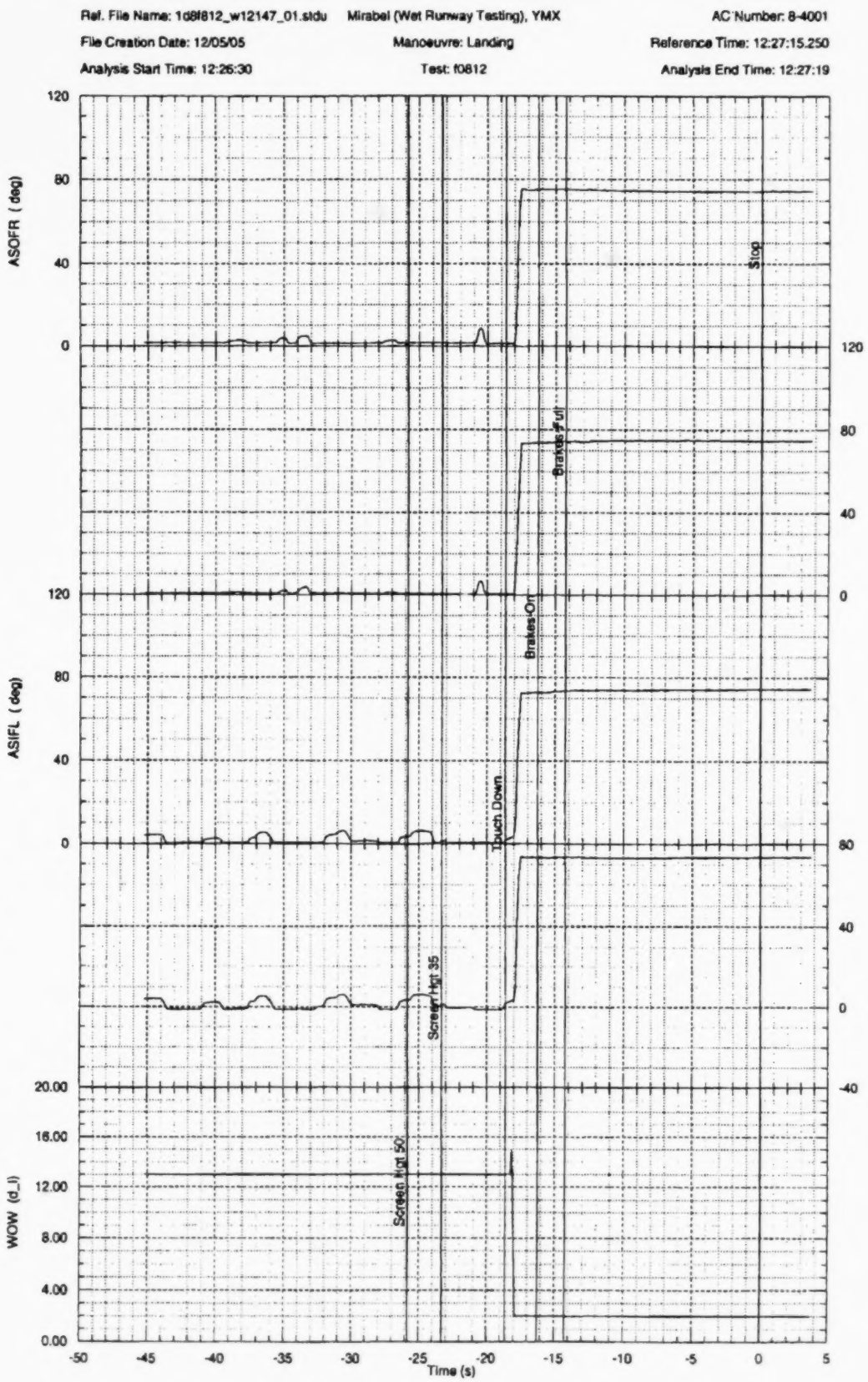
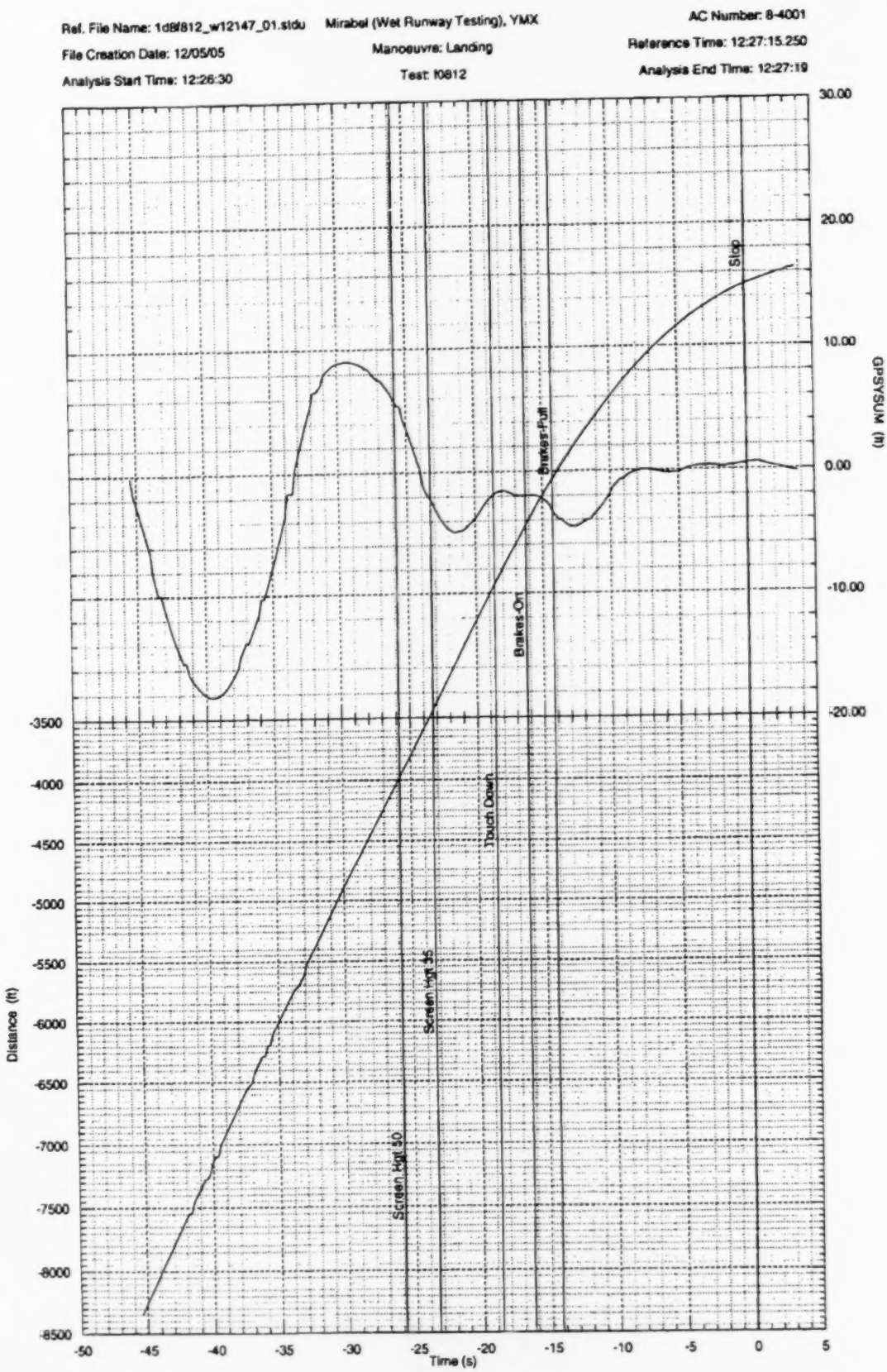
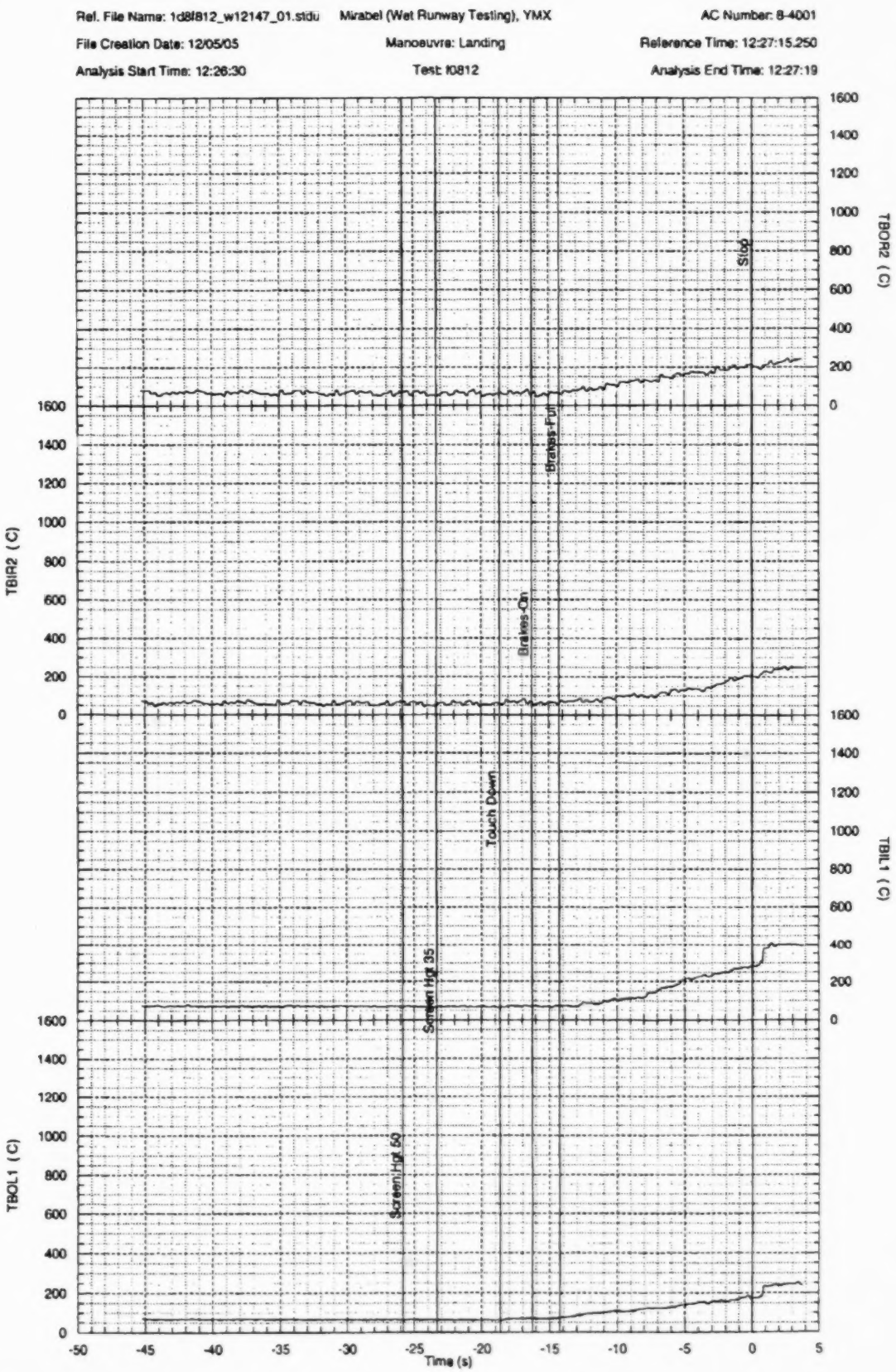

Ref. File Name: 1d8f812_w12147_01.stdu
Mirabel (Wet Runway Testing), YMX
AC Number: 8-4001
File Creation Date: 12/05/05
Manoeuvre: Landing
Reference Time: 12:27:15.250
Analysis Start Time: 12:26:30
Test: f0812
Analysis End Time: 12:27:19
ASOFR (deg)
ASIFR (deg)
ASIFL (deg)
ASOFL (deg)
WOW (d_l)
Time (s)
Stop
Brakes Full
Brakes On
Touch Down
Screen Hgt 35
Screen Hgt 50



DAFT version: 2.10
/tmp_mnt/tors/flightsc/Flt_Data/4001/f800-f899/f812/TP4_2.pl



DAFT version: 2.10

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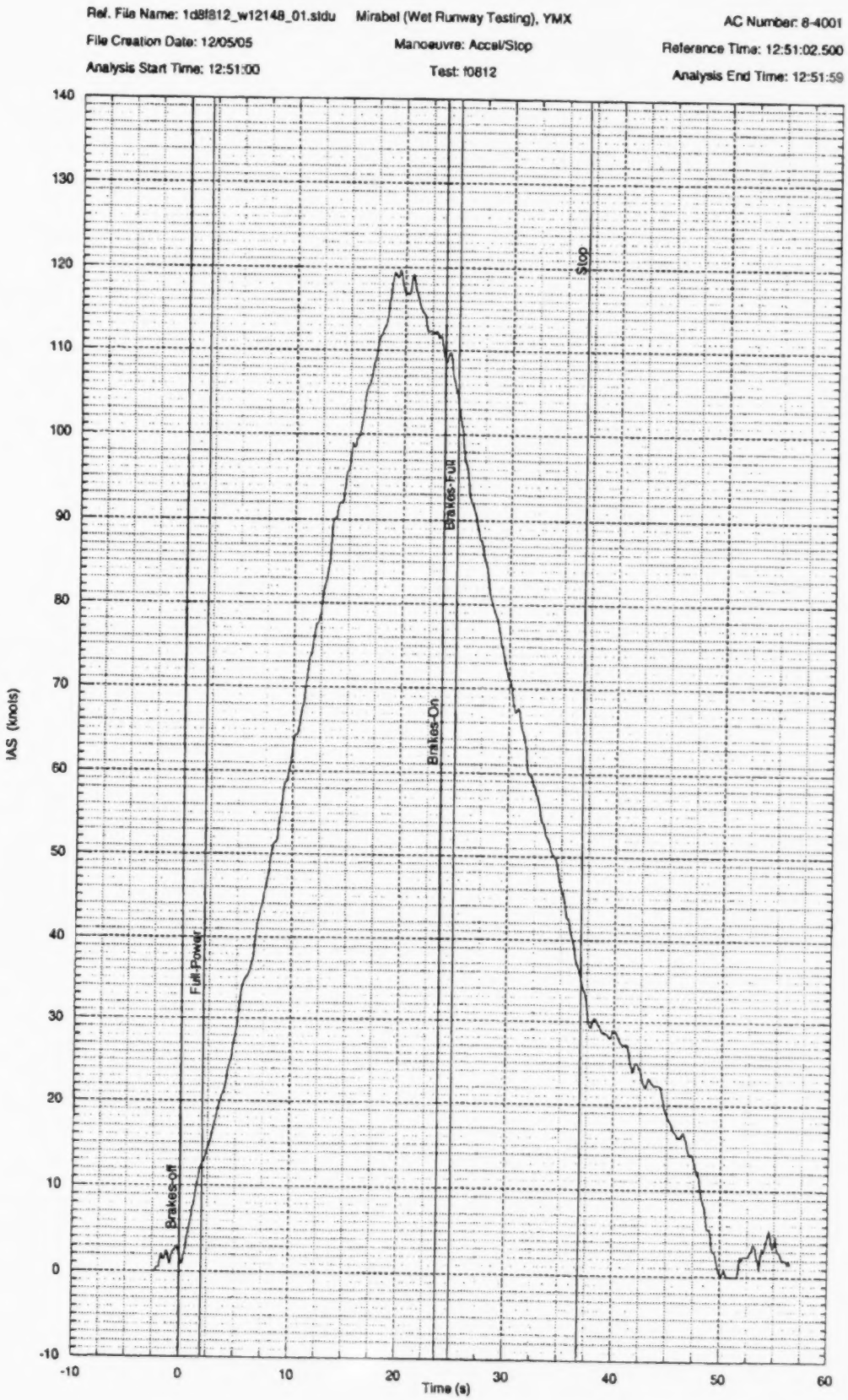
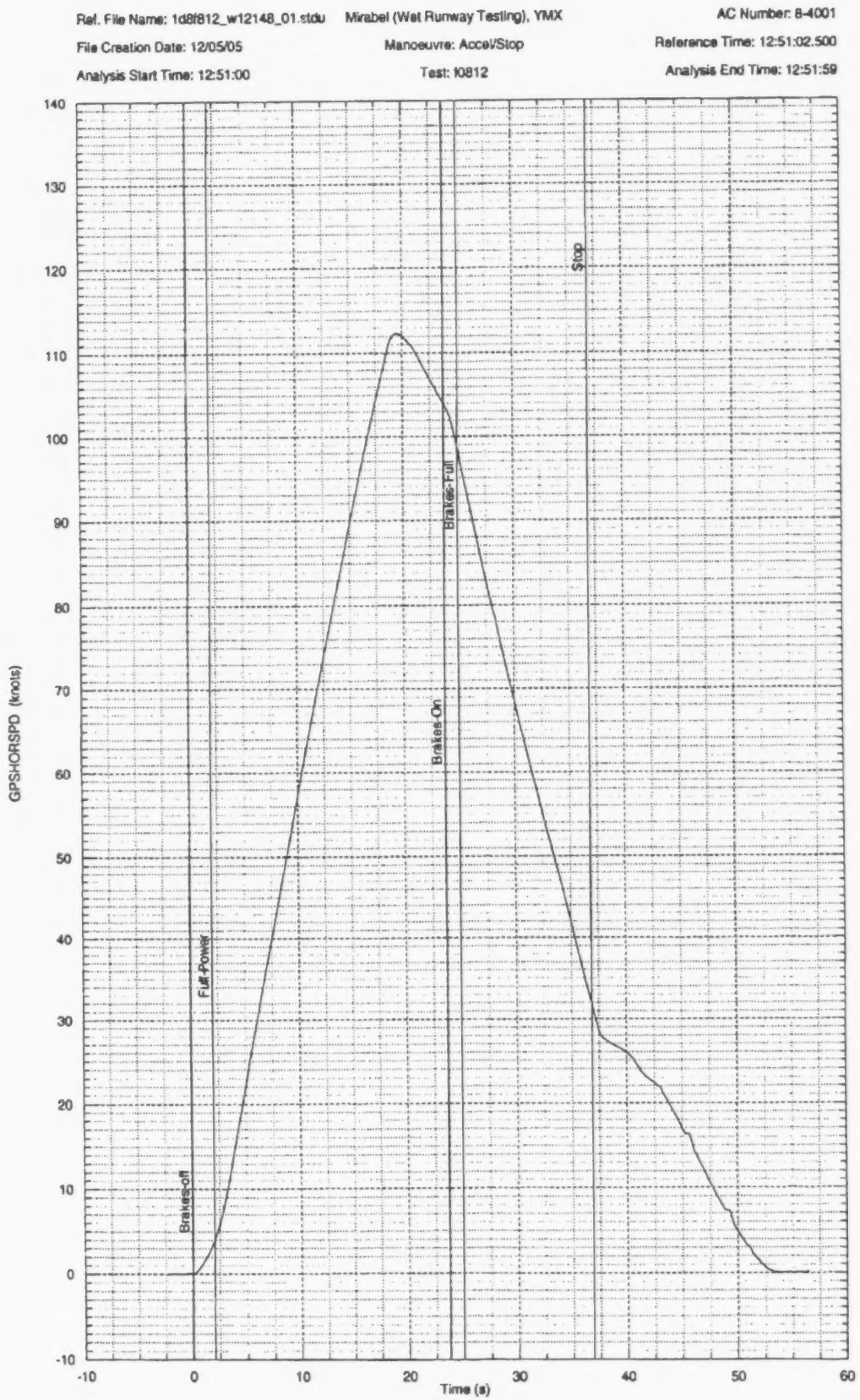
Test Point 5.1


Ref. File Name: 1d8f812_w12148_01.stdu
Mirabel (Wet Runway Testing), YMX
AC Number: 8-4001
File Creation Date: 12/05/05
Manoeuvre: Accel/Stop
Reference Time: 12:51:02.500
Analysis Start Time: 12:51:00
Test: f0812
Analysis End Time: 12:51:59
IAS (knots)
Time (s)
Brakes-off
Full Power
Brakes-On
Brakes-Full
Stop



DAFT version: 2.10
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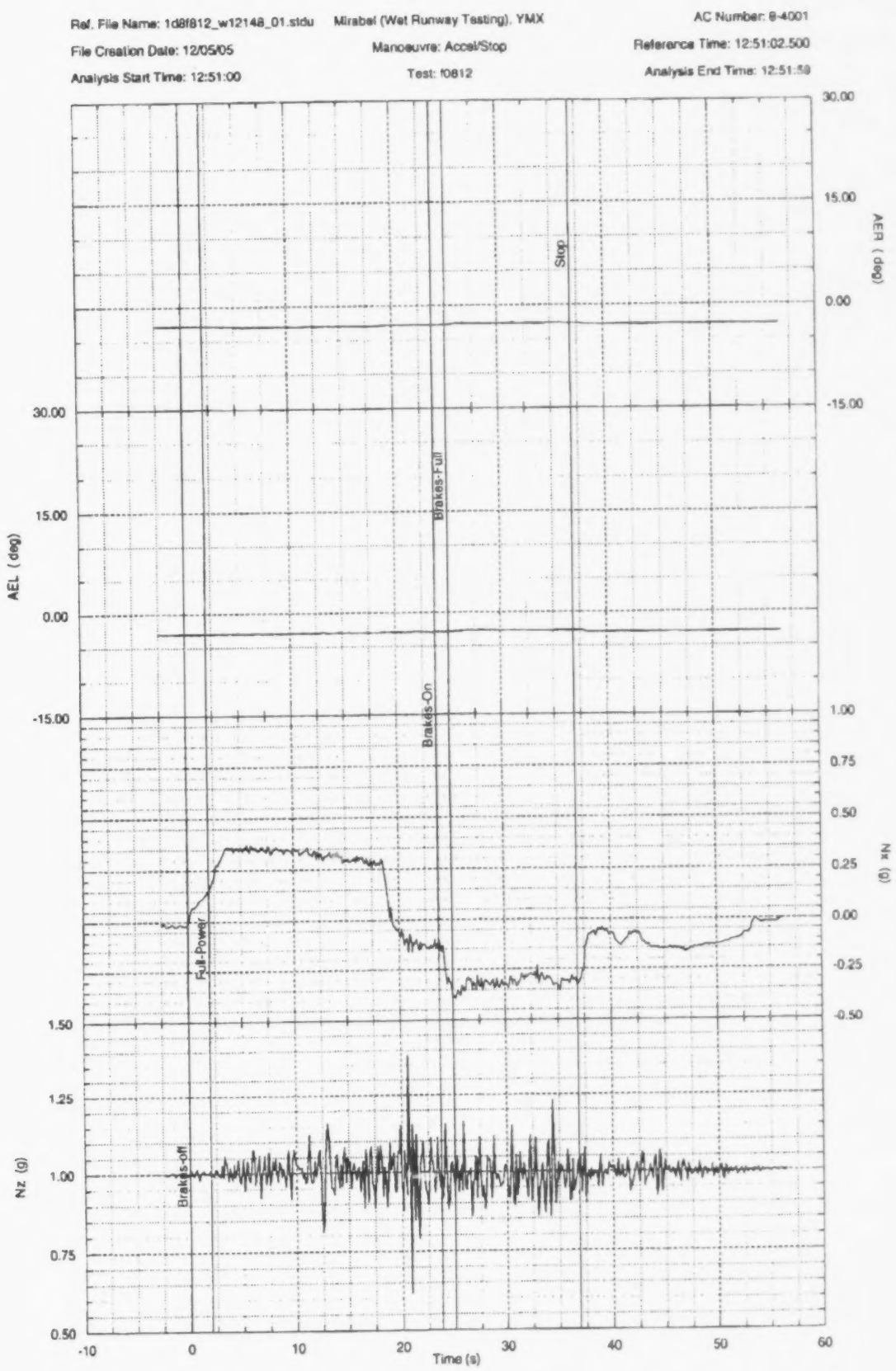
DAFT version 2.10



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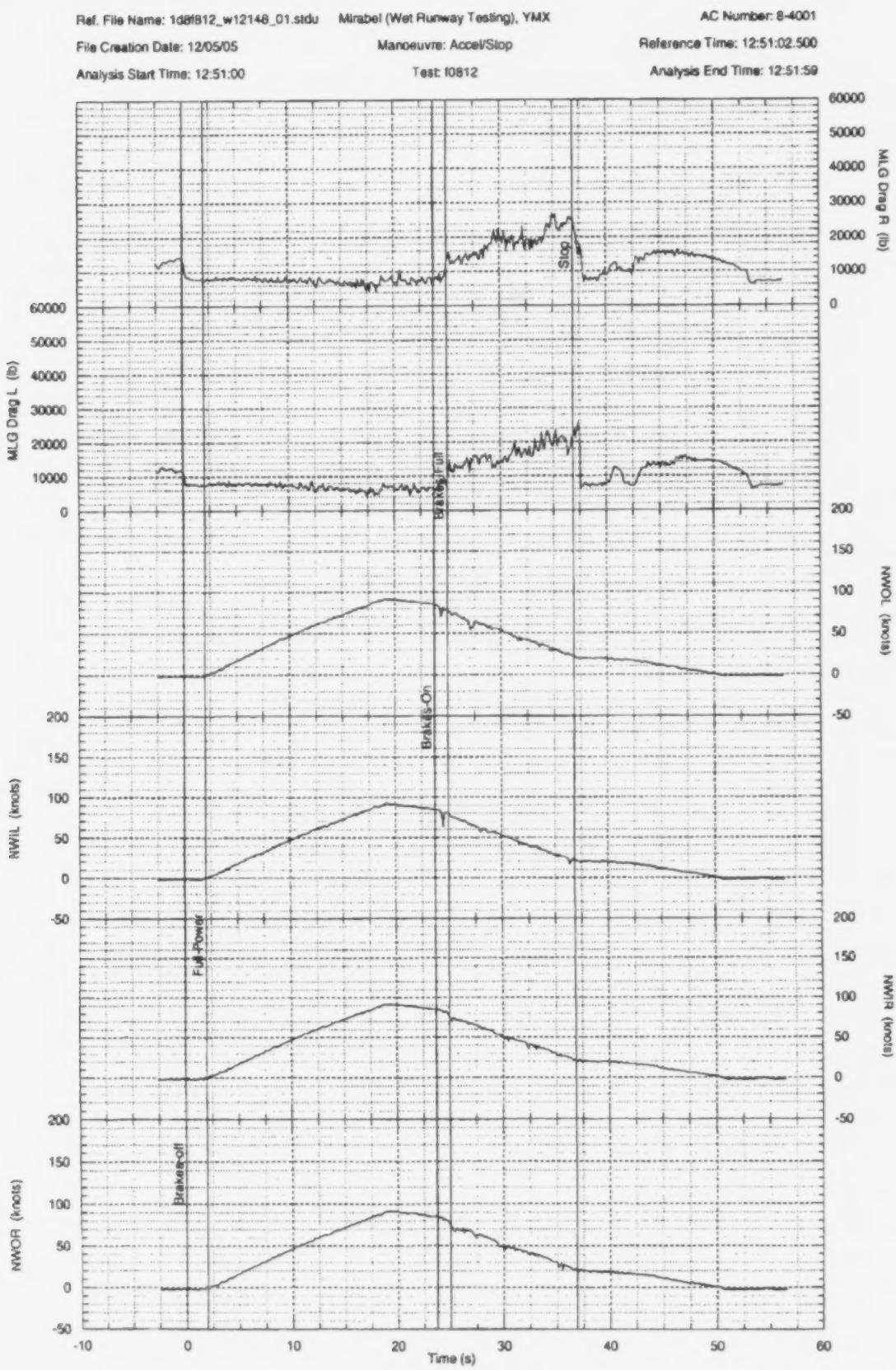
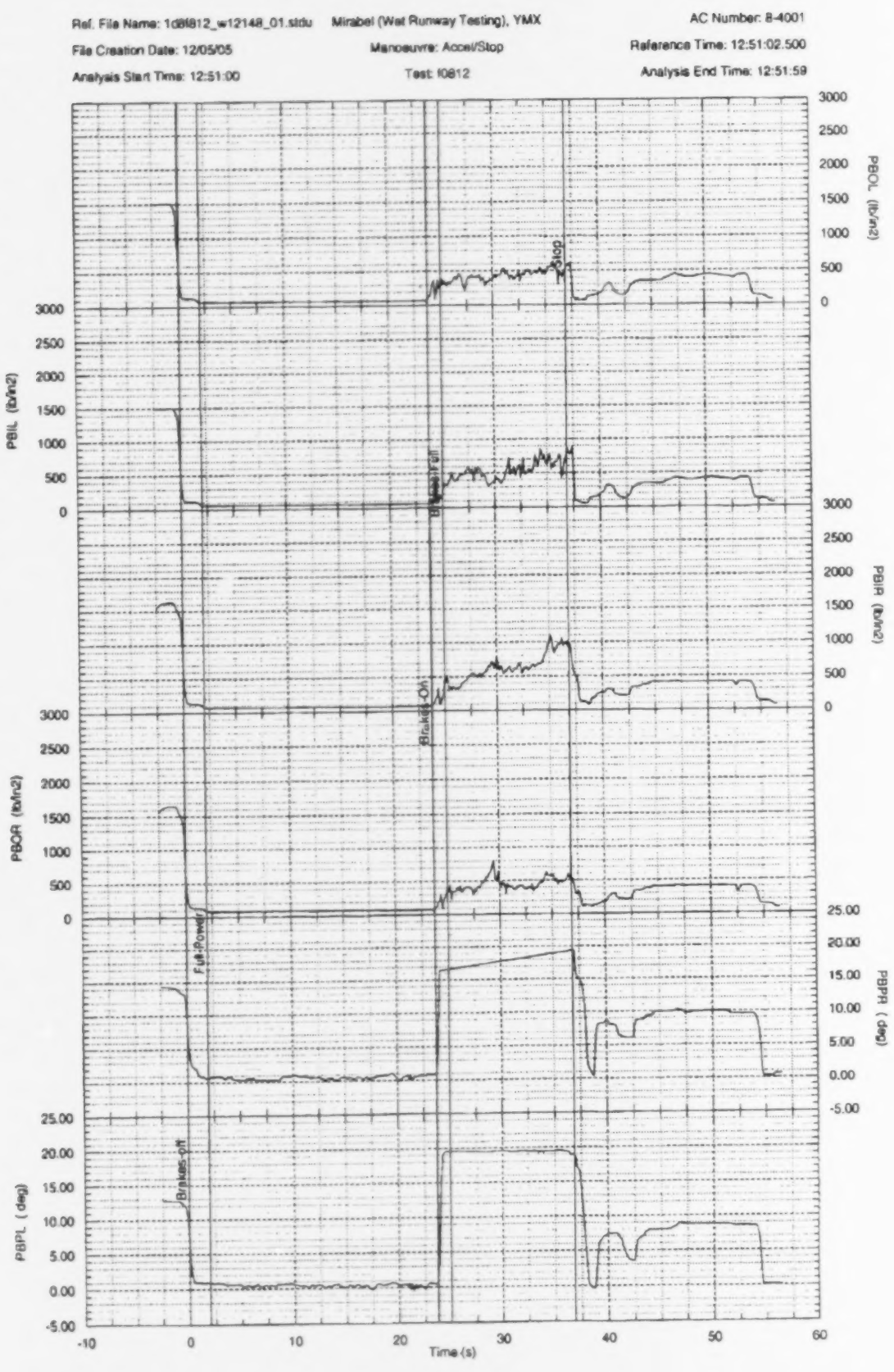


DAFT version: 2.10
/tmp_mnt/root/flightsc/Flt_Data/400/f800-f899/f812/TPS.1.pit

Ref. File Name: 1d8f812_w12148_01.stdu Mirabel (Wet Runway Testing), YMX AC Number: 8-4001

File Creation Date: 12/05/05 Manoeuvre: Accel/Stop Reference Time: 12:51:02.500

Analysis Start Time: 12:51:00 Test: f0812 Analysis End Time: 12:51:59



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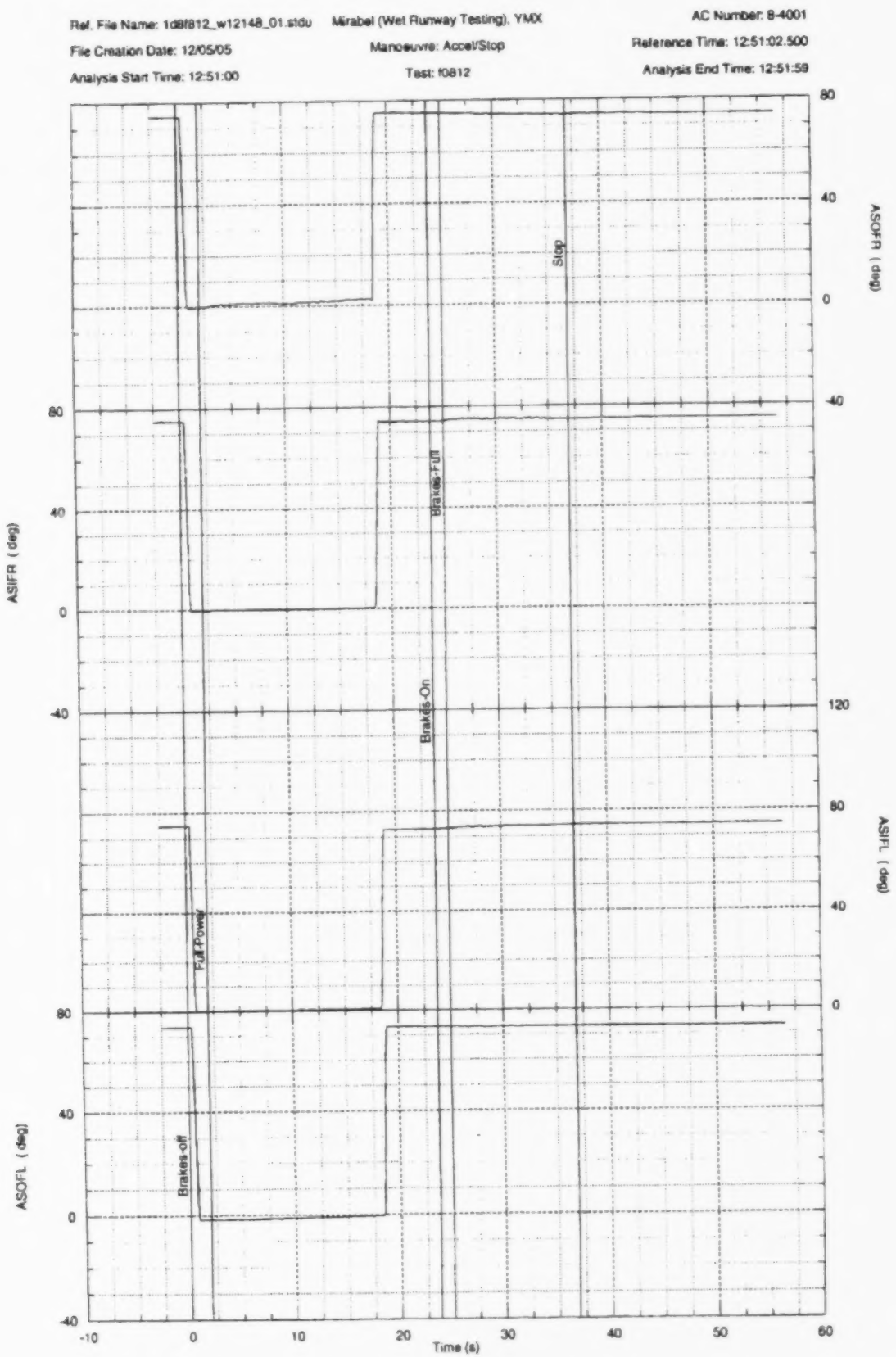
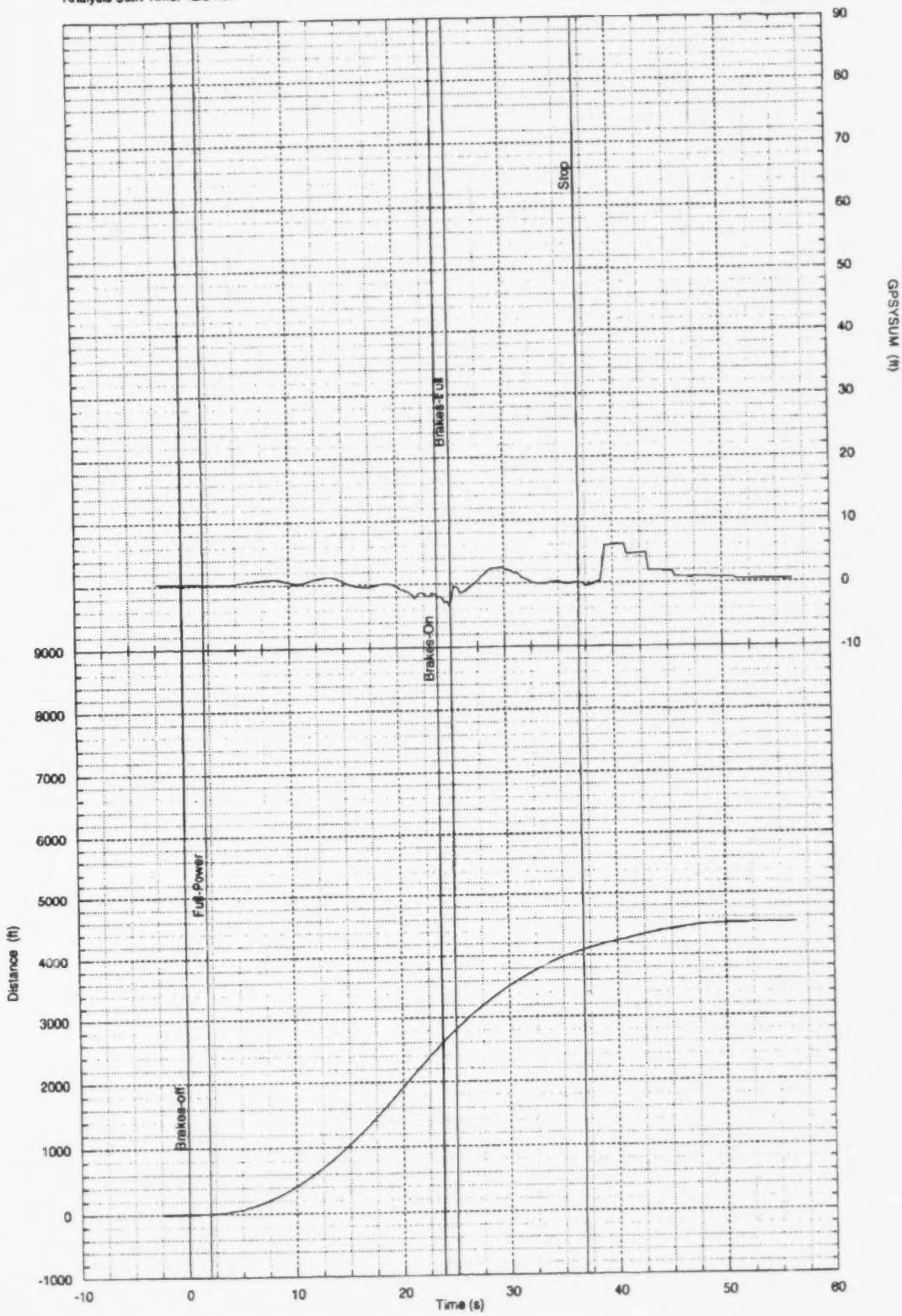

Ref. File Name: 1d8f812_w12148_01.stdu
File Creation Date: 12/05/05
Analysis Start Time: 12:51:00
Mirabel (Wet Runway Testing), YMX
Manoeuvre: Accel/Stop
Test: f0812
AC Number: 8-4001
Reference Time: 12:51:02.500
Analysis End Time: 12:51:59
ASIFR (deg)
ASOFR (deg)
ASIFL (deg)
ASOFL (deg)
Stop
Brakes-Full
Brakes-On
Full-Power
Brakes-off
Time (s)

Ref. File Name: 1d8f812_w12148_01.stdu
File Creation Date: 12/05/05
Analysis Start Time: 12:51:00

Mirabel (Wet Runway Testing), YMX
Manoeuvre: Accel/Stop
Test: f0812

AC Number: 8-4001
Reference Time: 12:51:02.500
Analysis End Time: 12:51:59



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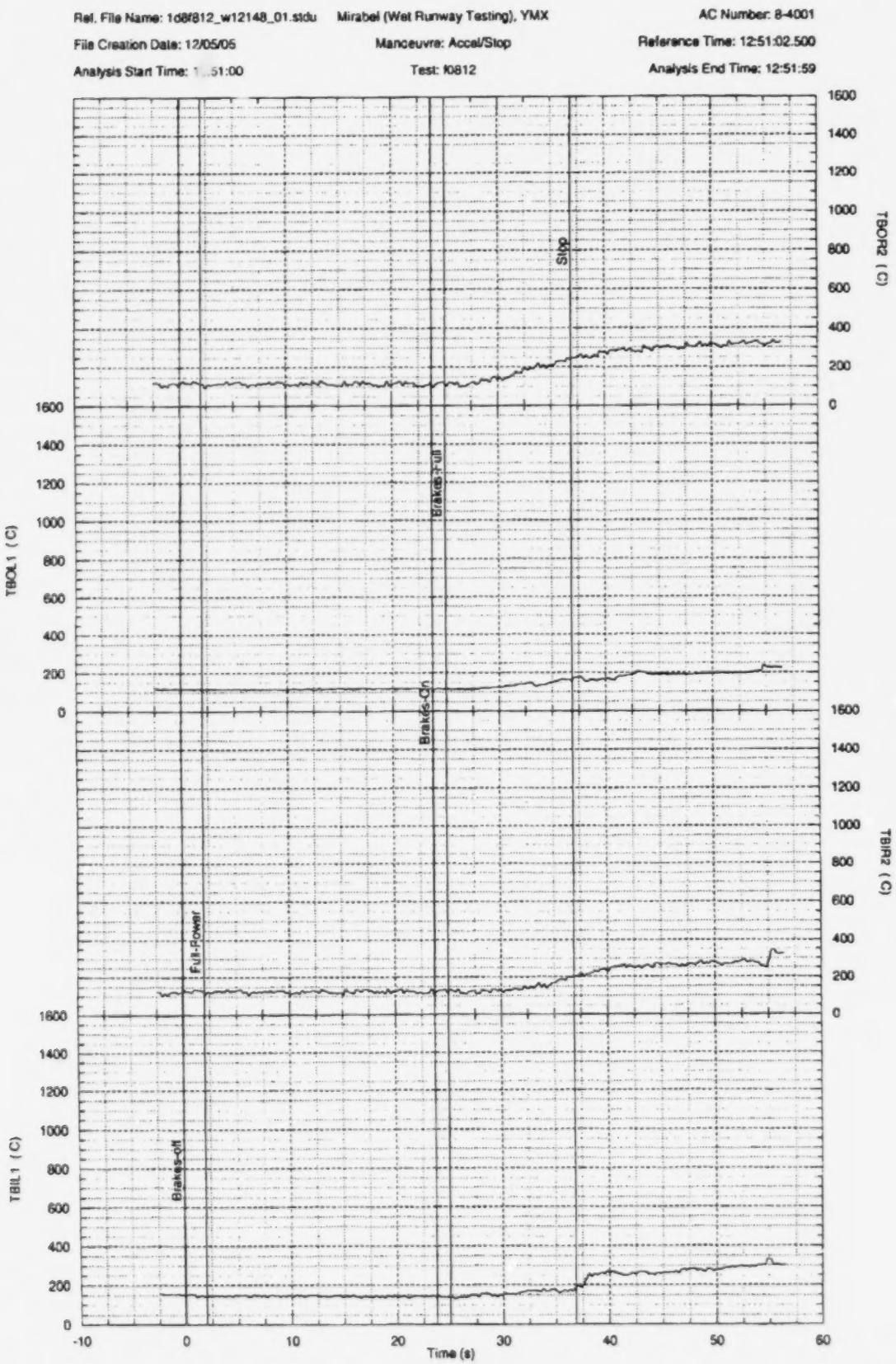
Ref. File Name: 1d8f812_w12148_01.stdu Mirabel (Wet Runway Testing), YMX AC Number: 8-4001

File Creation Date: 12/05/05 Manoeuvre: Accel/Stop Reference Time: 12:51:02.500

Analysis Start Time: 1[illegible]:51:00 Test: f0812 Analysis End Time: 12:51:59



DAF-I version: 2.10

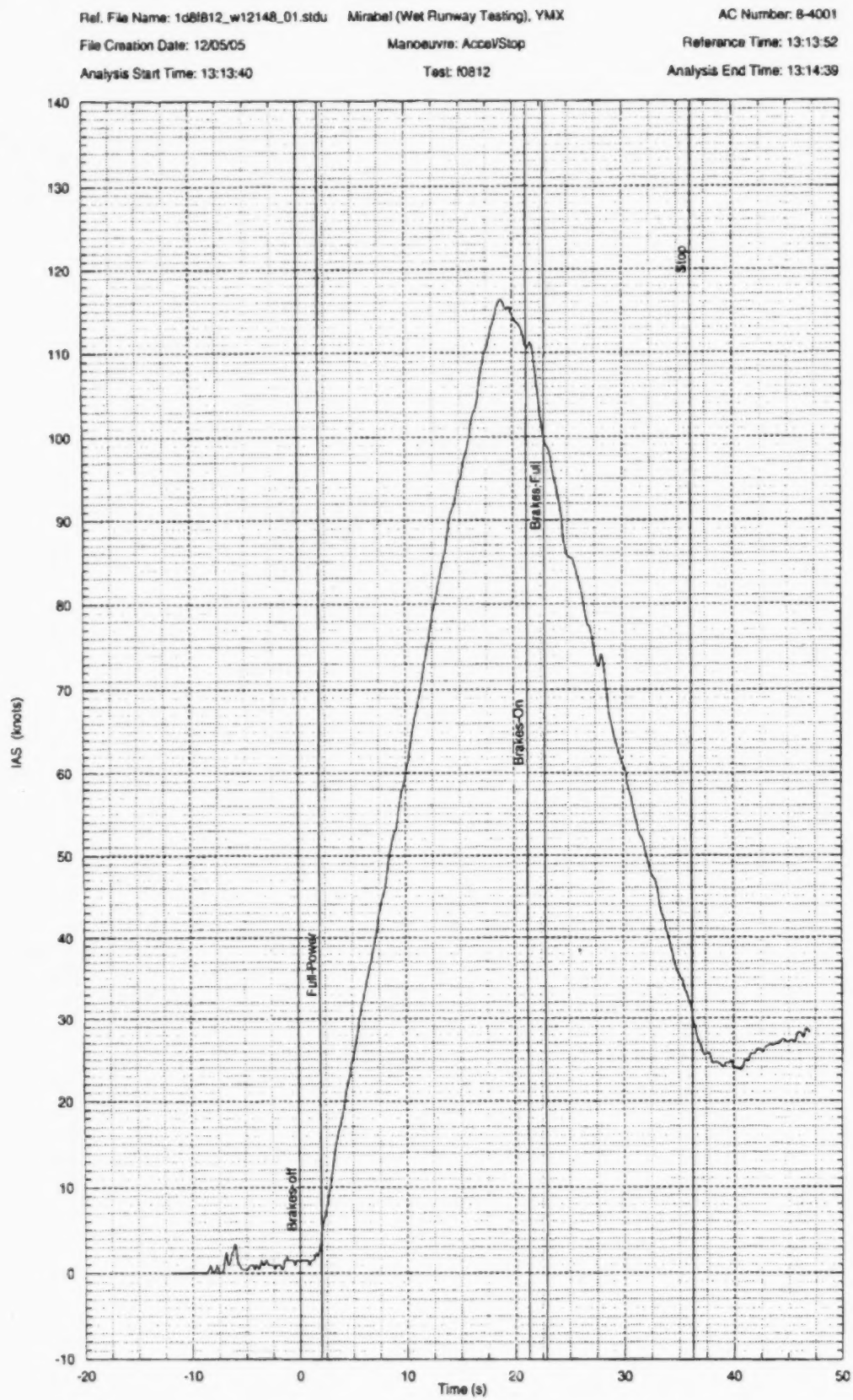
/tmp_mnt/forfs/flightsc/Flt_Data/4001/f800-f899/f812/TP5.1.plt

Test Point 5.2

Ref. File Name: 1d8f812_w12148_01.stdu Mirabel (Wet Runway Testing), YMX AC Number: 8-4001

File Creation Date: 12/05/05 Manoeuvre: Accel/Stop Reference Time: 13:13:52

Analysis Start Time: 13:13:40 Test: f0812 Analysis End Time: 13:14:39



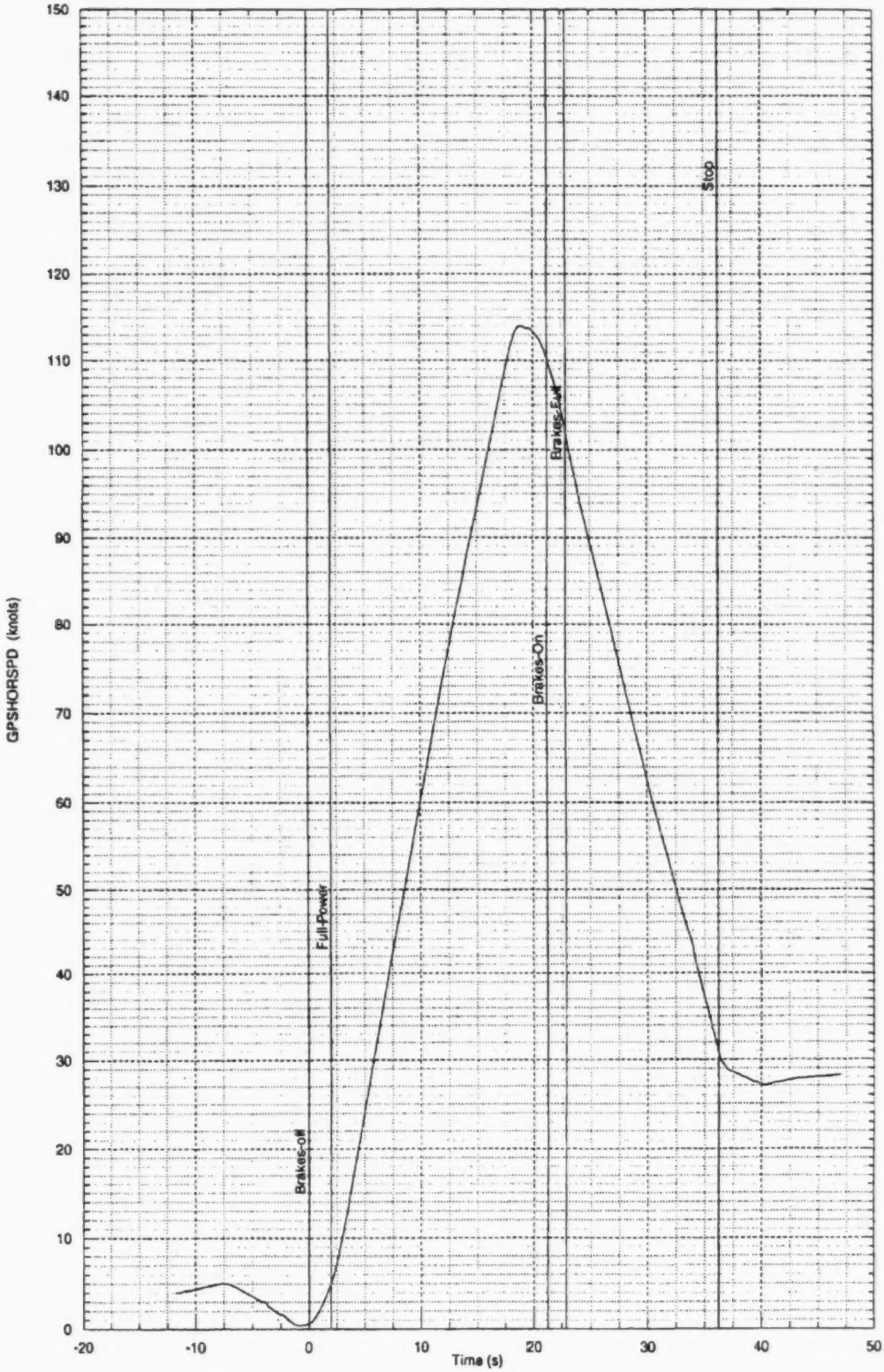
DAFT version: 2.10

/tmp_mnt/torfs/flightsc/Flt_Data/4001/f800-f899/f812/TP5.2.plt

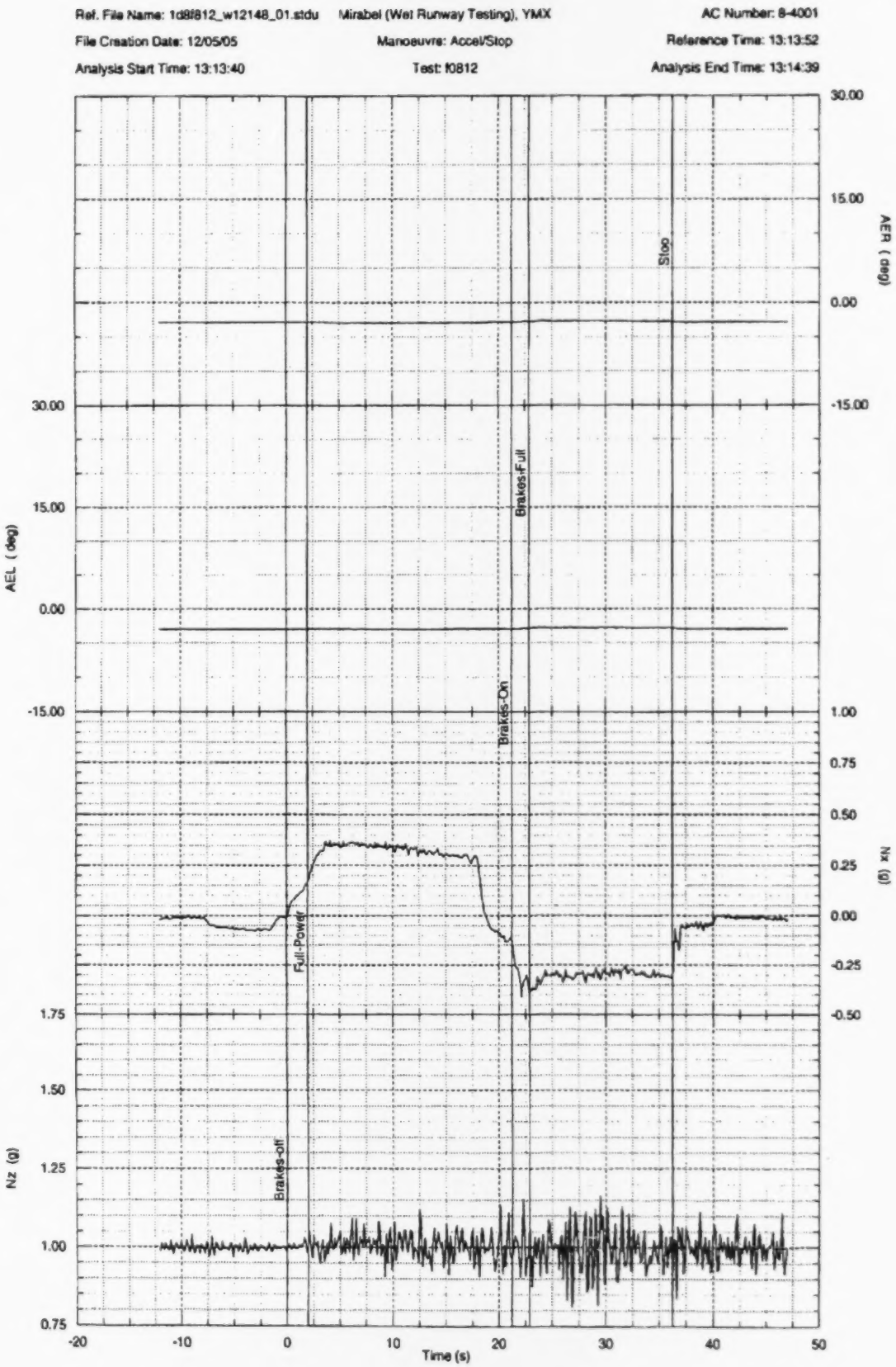
Ref. File Name: 1d8f812_w12148_01.stdu | Mirabel (Wet Runway Testing), YMX | AC Number: 8-4001

File Creation Date: 12/05/05 | Manoeuvre: Accel/Stop | Reference Time: 13:13:52

Analysis Start Time: 13:13:40 | Test: f0812 | Analysis End Time: 13:14:39

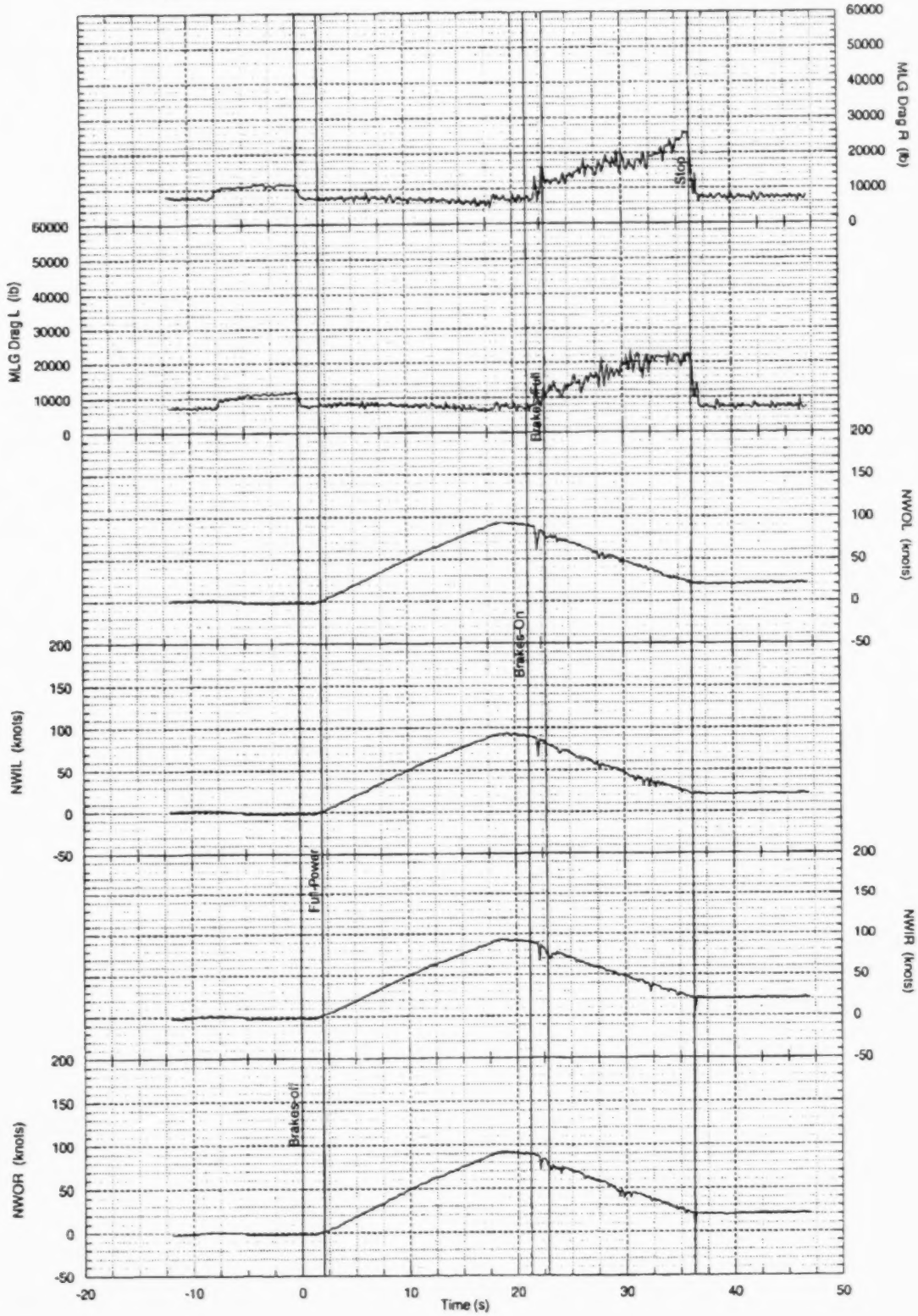


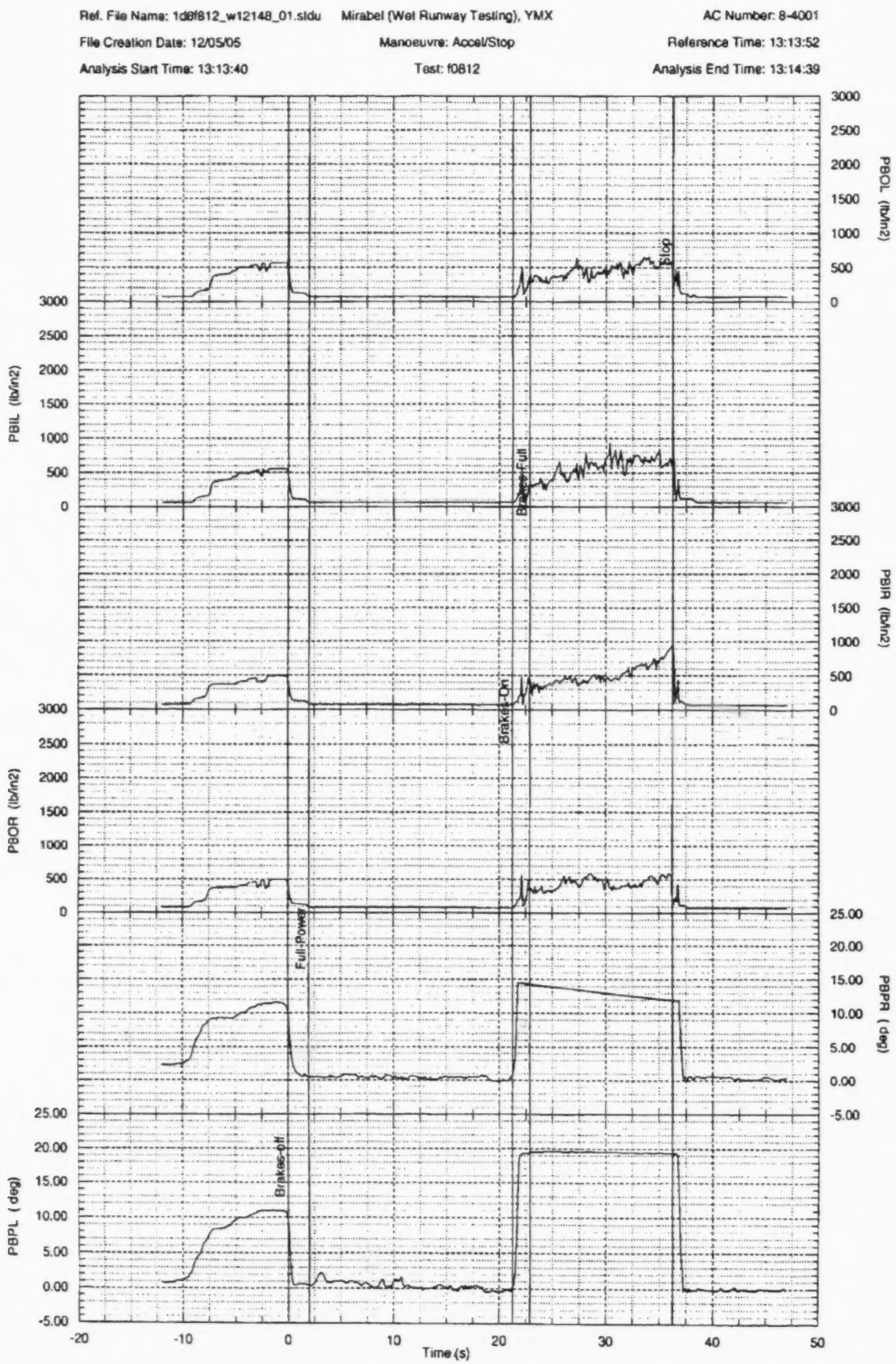
DAFT version: 2.10



DAFT version: 2.10
/tmp_mnt/tors/flights/c/Flt_Data/4001/f800-f899/f812/TP5.2.plt

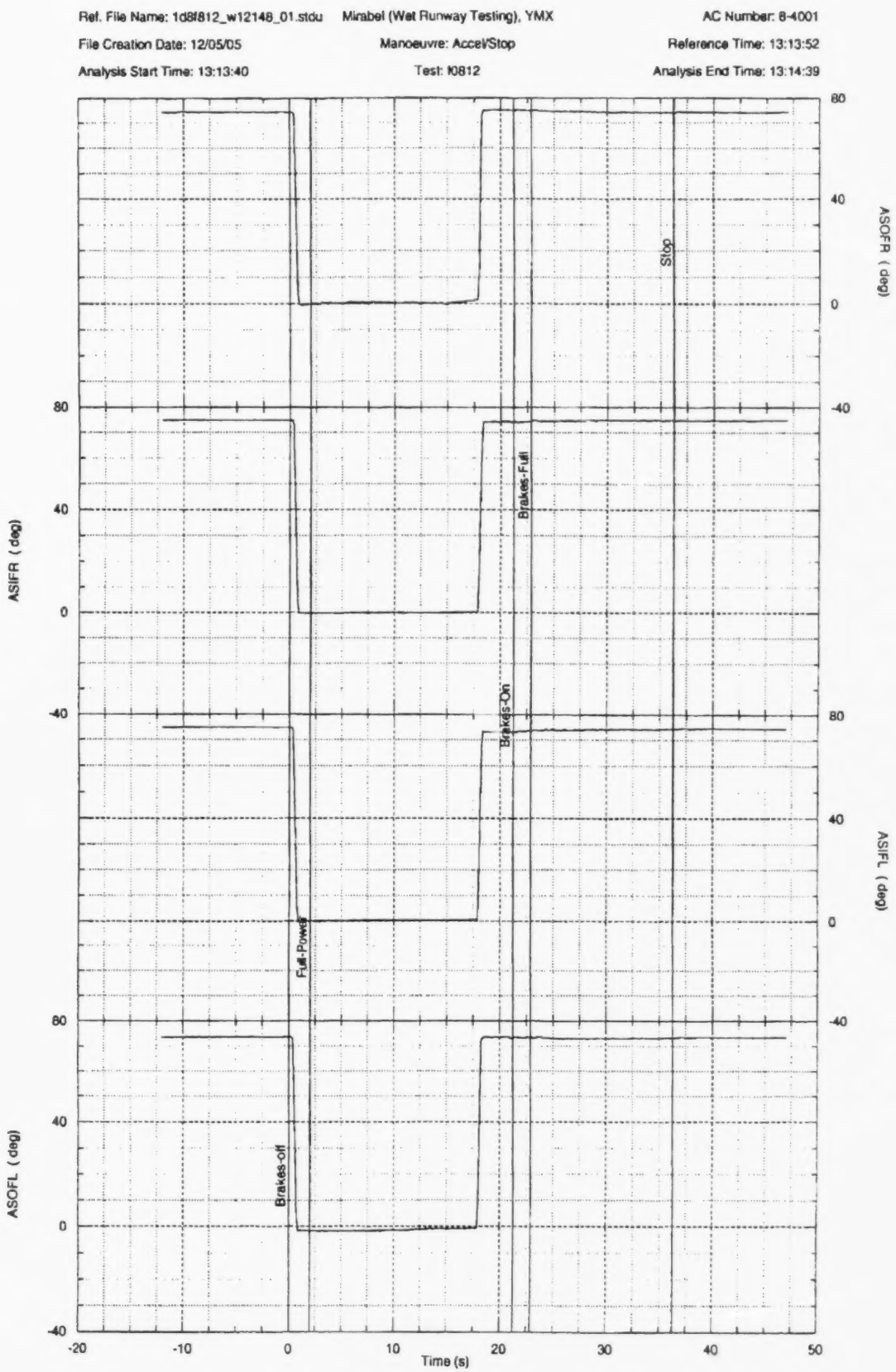
Ref. File Name: 1d8f812_w12148_01.stdu
Mirabel (Wet Runway Testing), YMX
AC Number: 8-4001
File Creation Date: 12/05/05
Manoeuvre: Accel/Stop
Reference Time: 13:13:52
Analysis Start Time: 13:13:40
Test: f0812
Analysis End Time: 13:14:39





DAFT version: 2.10

/tmp_mnt/dofs/flightsci/Ft_Data/4001/f800-1899/f812/TP5.2.plt



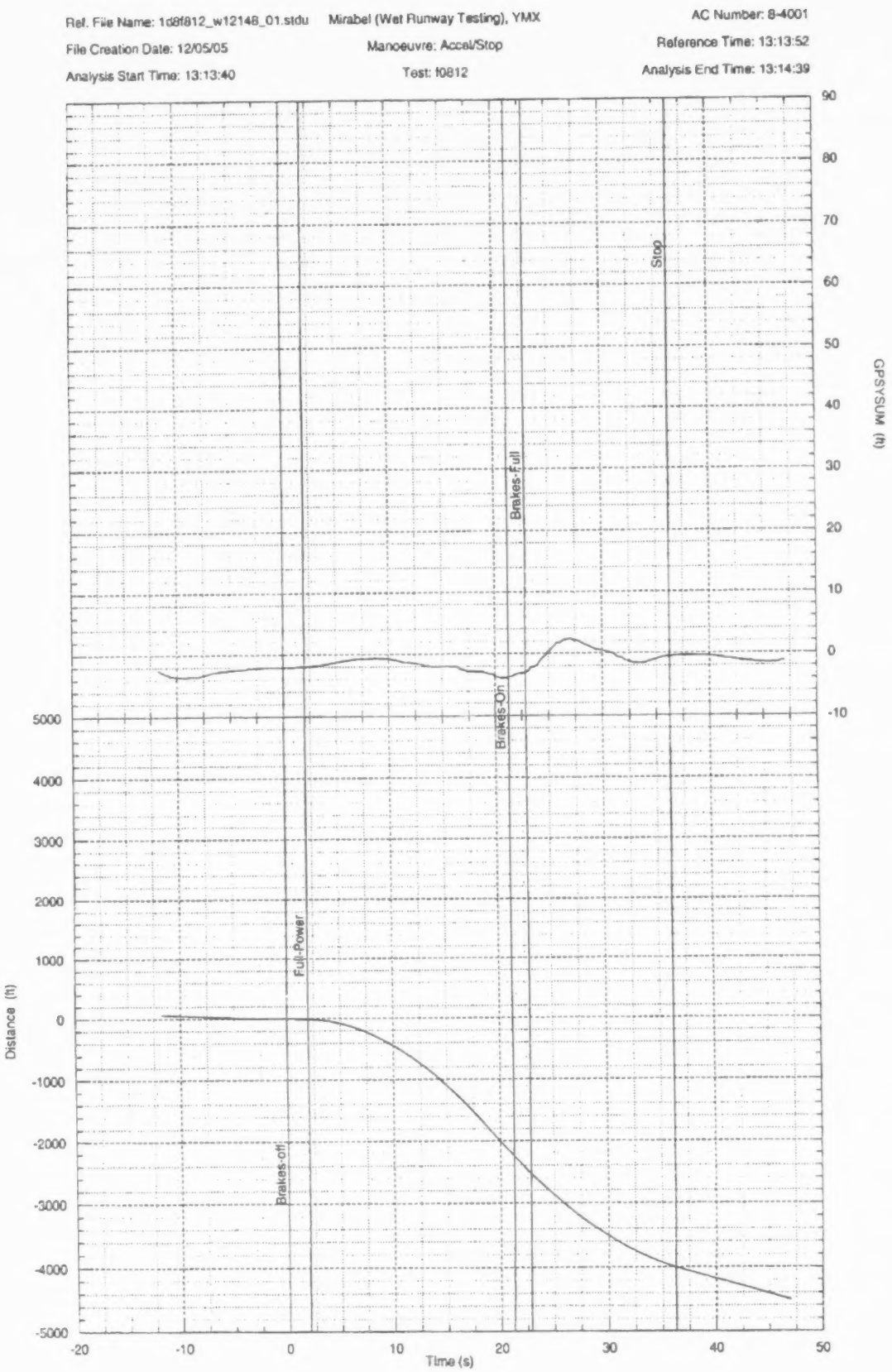
DAFT version 2.10

/tmp_mnt/nfs/flightsc FII_Data/4001/f800-f899/f812/1P5_2.plt

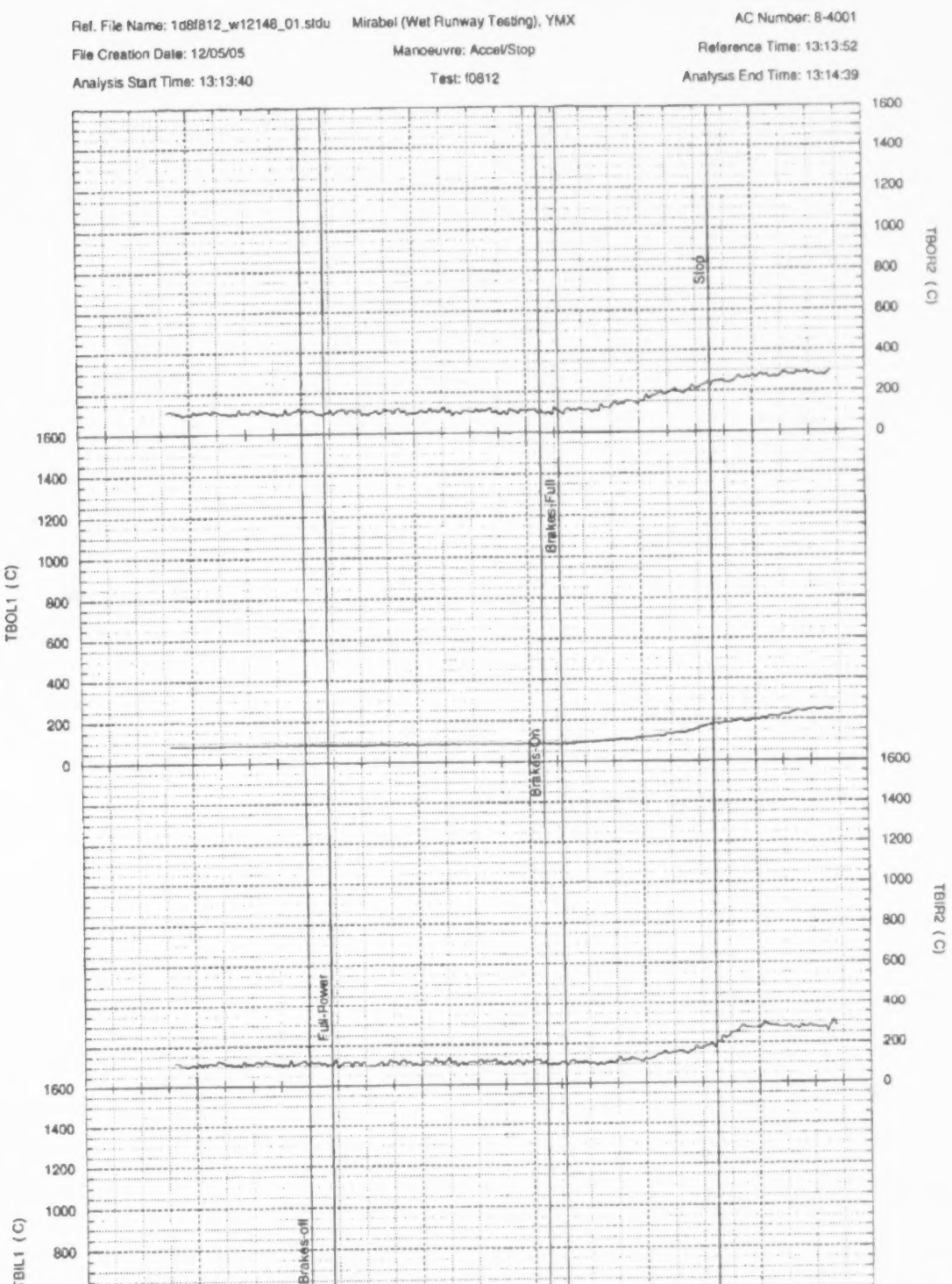
Ref. File Name: 1d8f812_w12148_01.stdu
File Creation Date: 12/05/05
Analysis Start Time: 13:13:40

Mirabel (Wet Runway Testing), YMX
Manoeuvre: Accel/Stop
Test: f0812

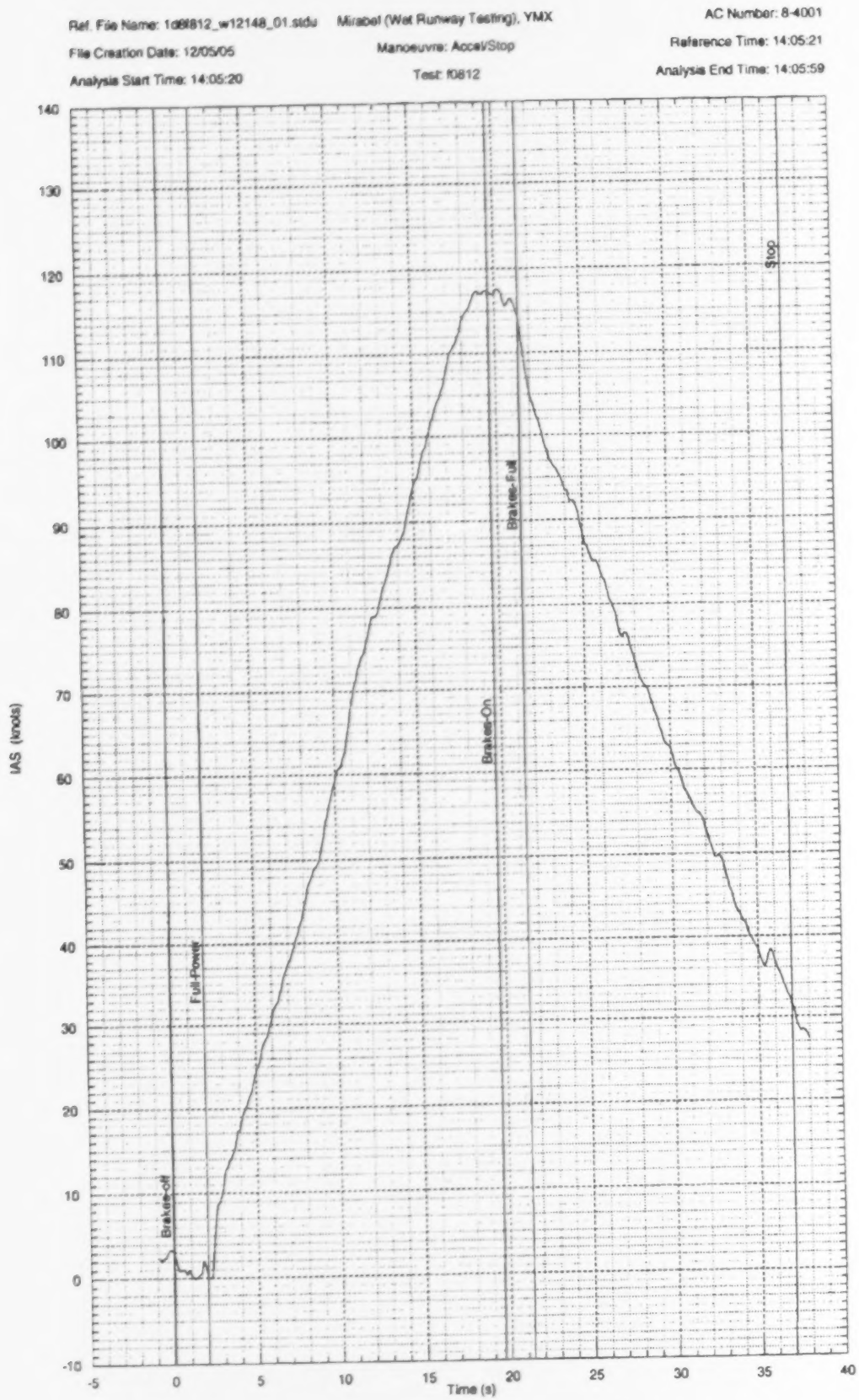
AC Number: 8-4001
Reference Time: 13:13:52
Analysis End Time: 13:14:39



/tmp_mnt/forfs/flightsc/Flt_Data/4001/f800-f899/f812/TP5.2.plt

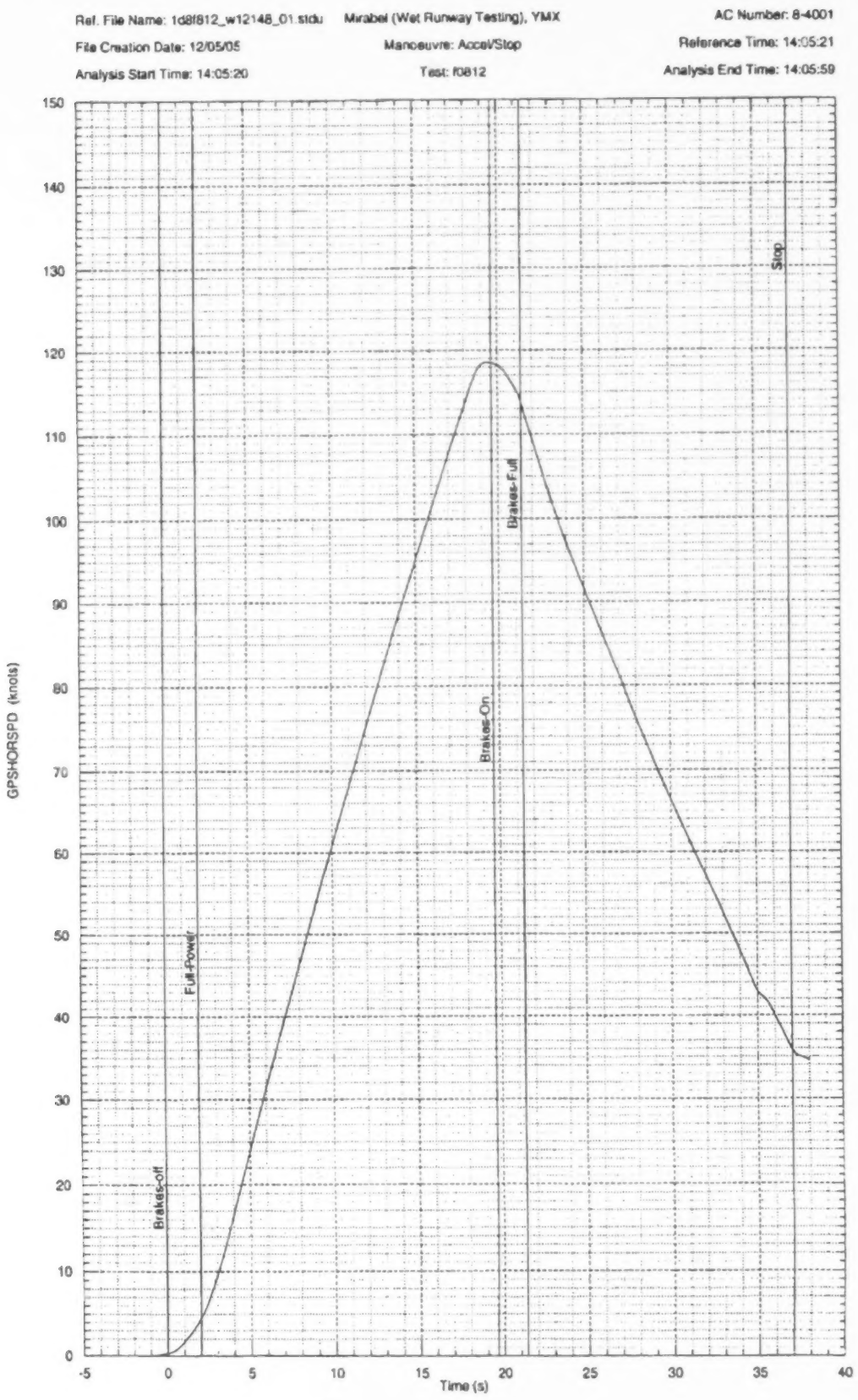

Ref. File Name: 1d8f812_w12148_01.stdu
Mirabel (Wet Runway Testing), YMX
AC Number: 8-4001
File Creation Date: 12/05/05
Manoeuvre: Accel/Stop
Reference Time: 13:13:52
Analysis Start Time: 13:13:40
Test: f0812
Analysis End Time: 13:14:39
TBOL1 (C)
TBOR2 (C)
TBIL1 (C)
TBIR2 (C)
Brakes-Full
Brakes-On
Full-Power
Brakes-off
Stop
Time (s)

Test Point 5.5

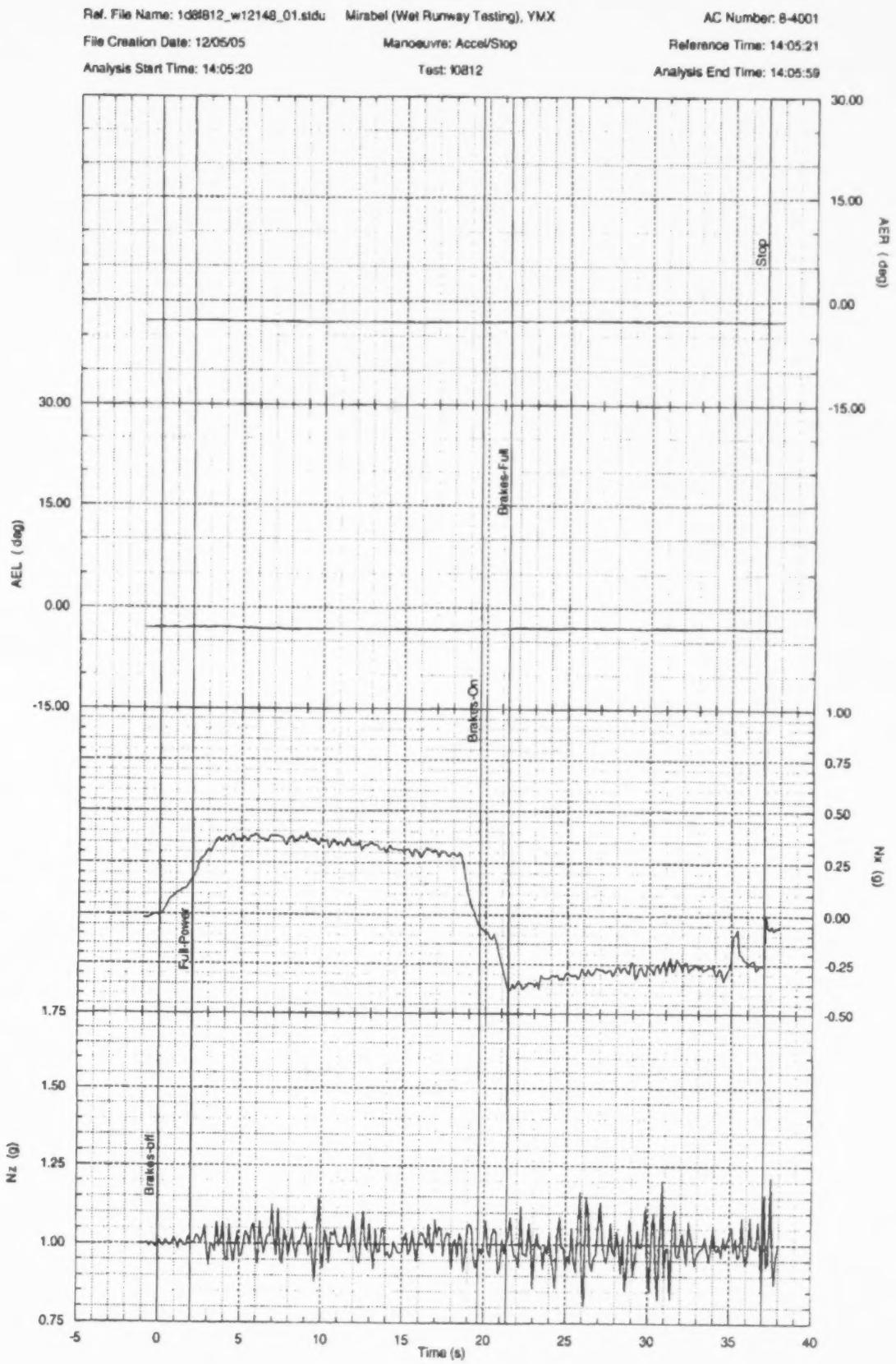


DAFT version: 2.10

/tmp_mnt/root/flightsc/Ft_Data/4001/f800-f899/f812/TP5.5.plt

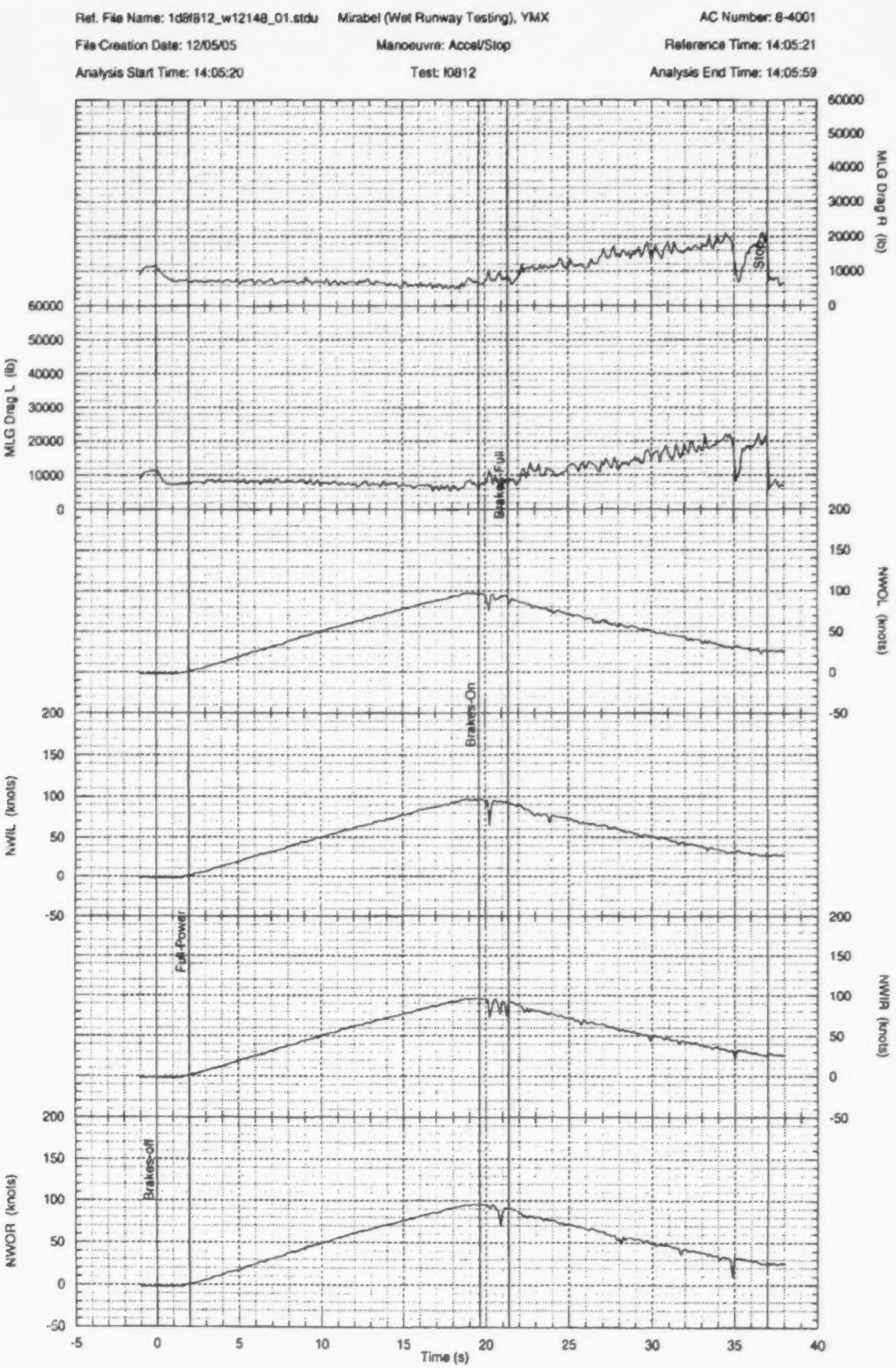


DAFT version: 2.10
/tmp_mnt/ork/s/flightsc/Ft_Data/4001/f800-f899/f812/TP5.5.plt

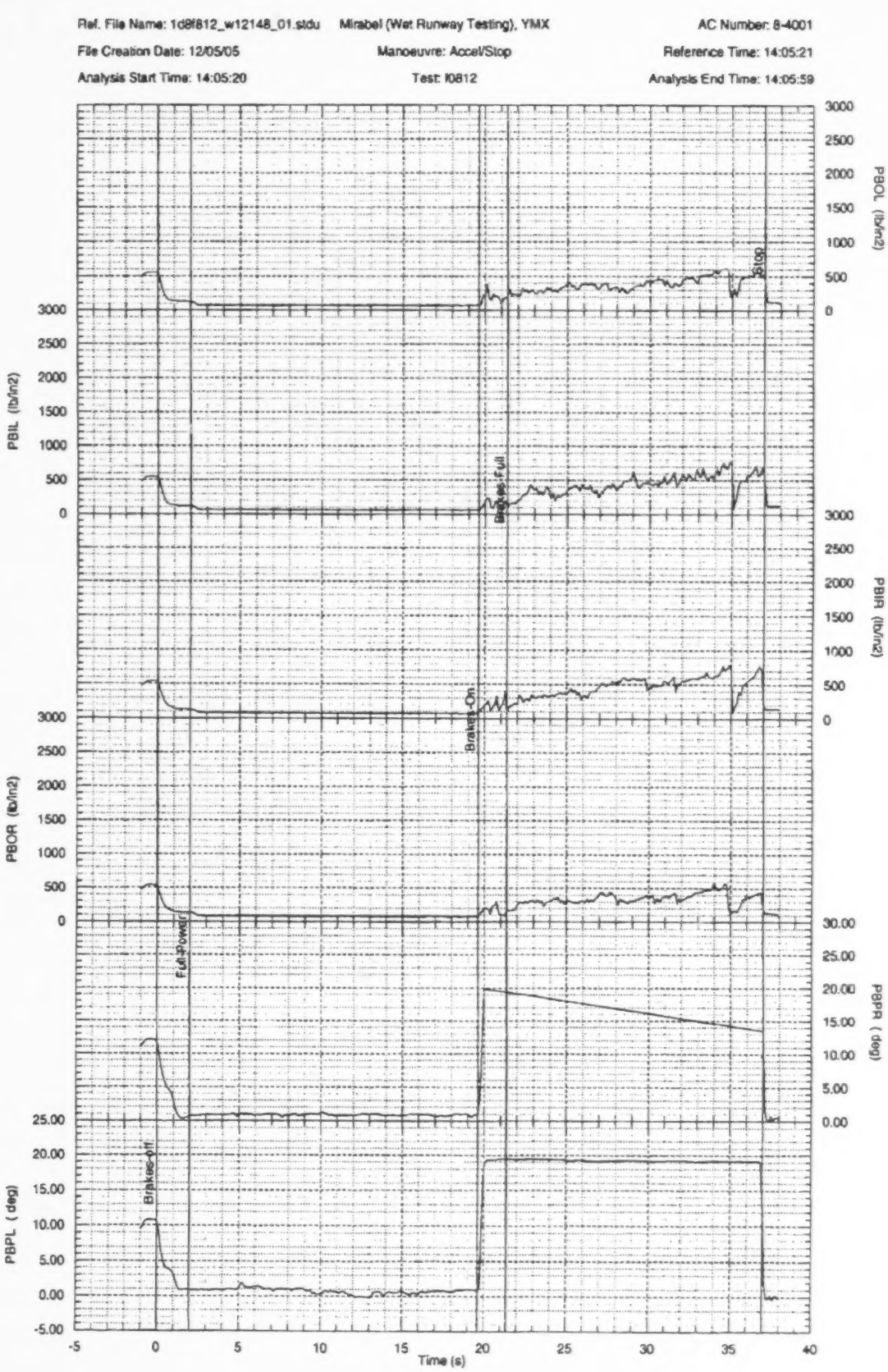


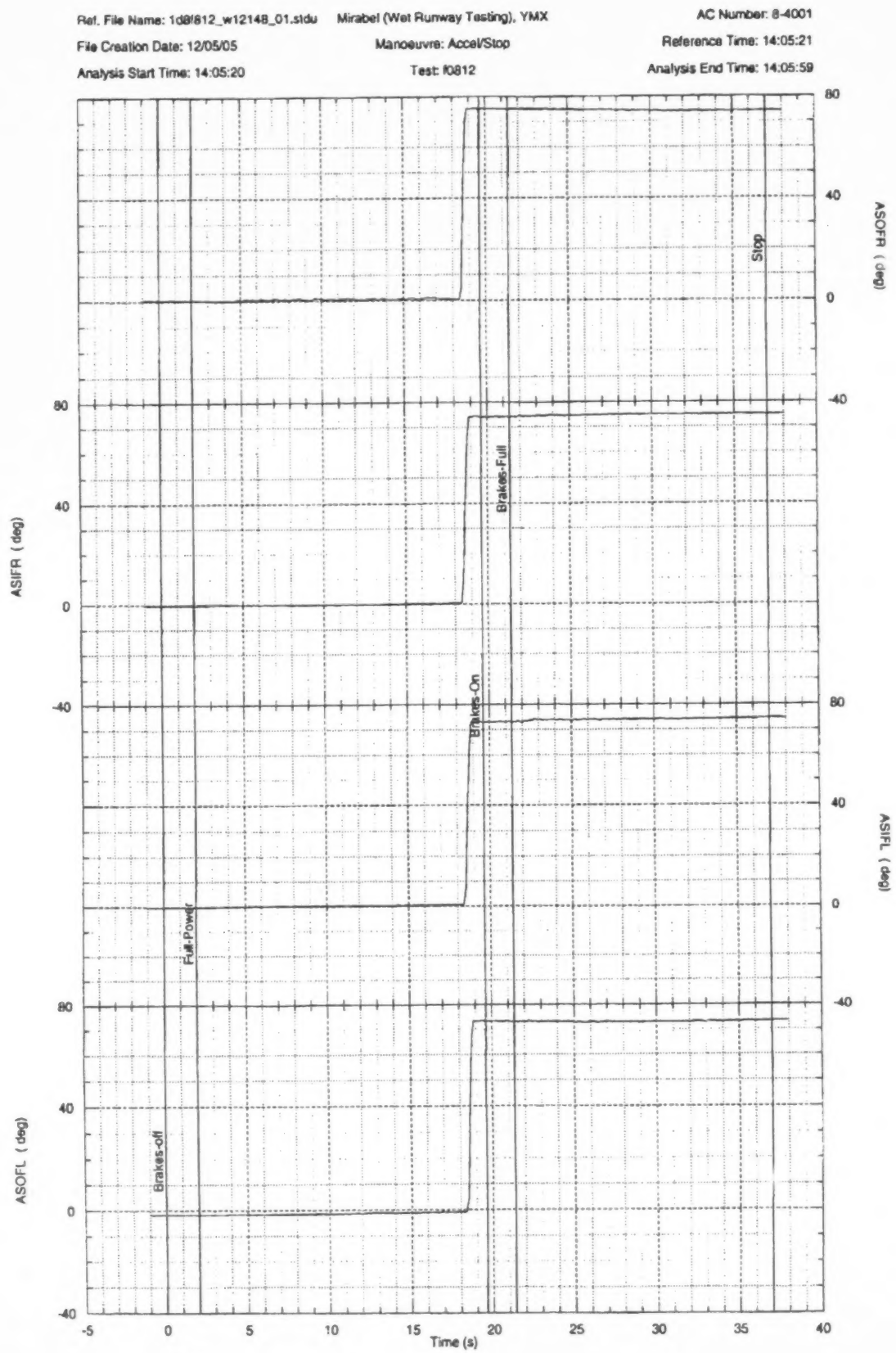
DAFT version: 2.10

/mp_monitors/flightsci/Flt_Data/4001/800-1999/8812/TP5.5.plt



DAFT version: 2.10
/tmp_mnt/vorfs/flightsc/Flt_Data/4001/f800-f899/f812/TP5.5.plt

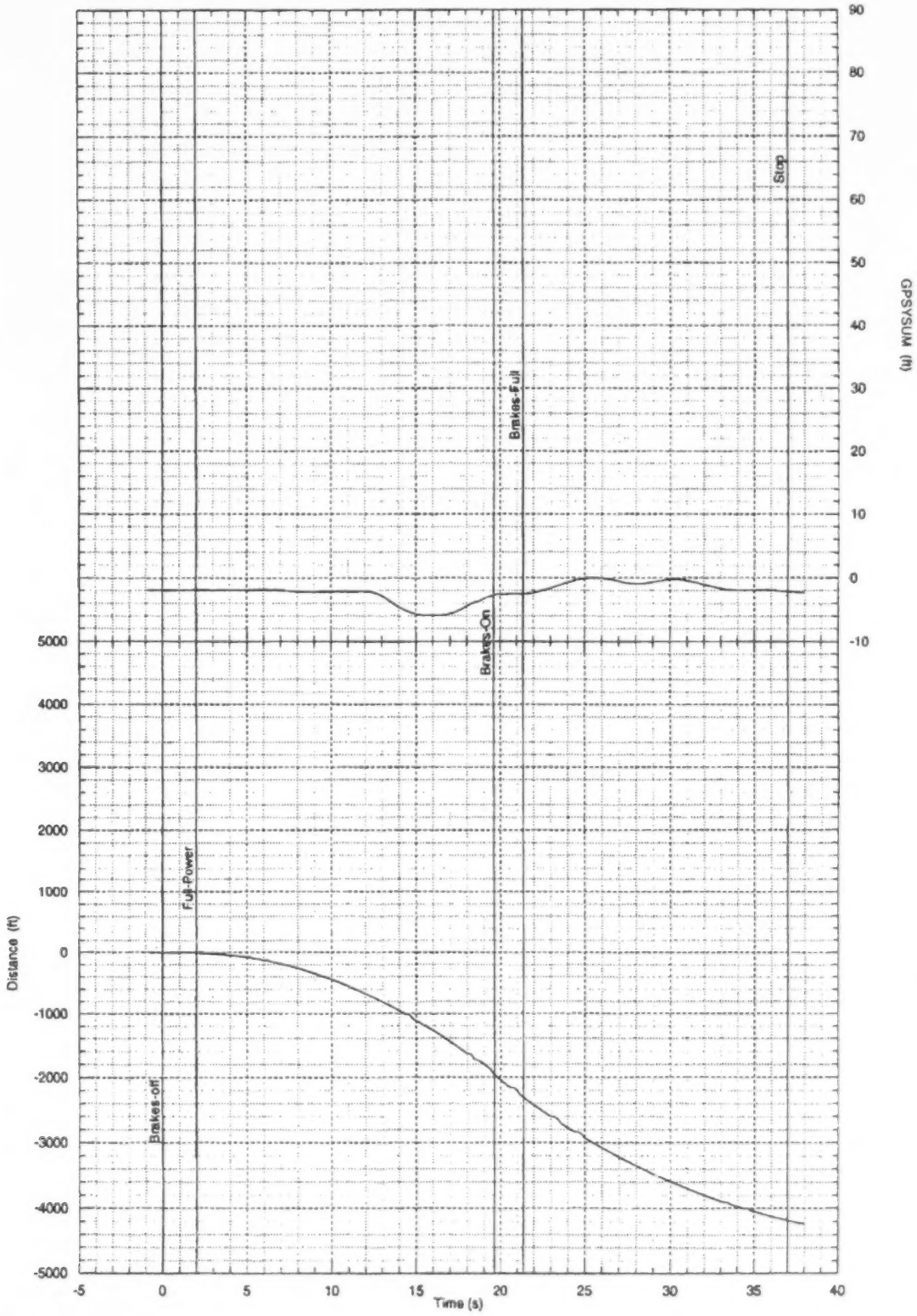

Ref. File Name: 1d8f812_w12148_01.stdu
Mirabel (Wet Runway Testing), YMX
AC Number: 8-4001
File Creation Date: 12/05/05
Manoeuvre: Accel/Stop
Reference Time: 14:05:21
Analysis Start Time: 14:05:20
Test: I0812
Analysis End Time: 14:05:59
PBOL (lb/in2)
PBIL (lb/in2)
PBIR (lb/in2)
PBOR (lb/in2)
PBPR (deg)
PBPL (deg)
Stop
Brakes Full
Brakes On
F.I.P.Power
Brakes off
Time (s)

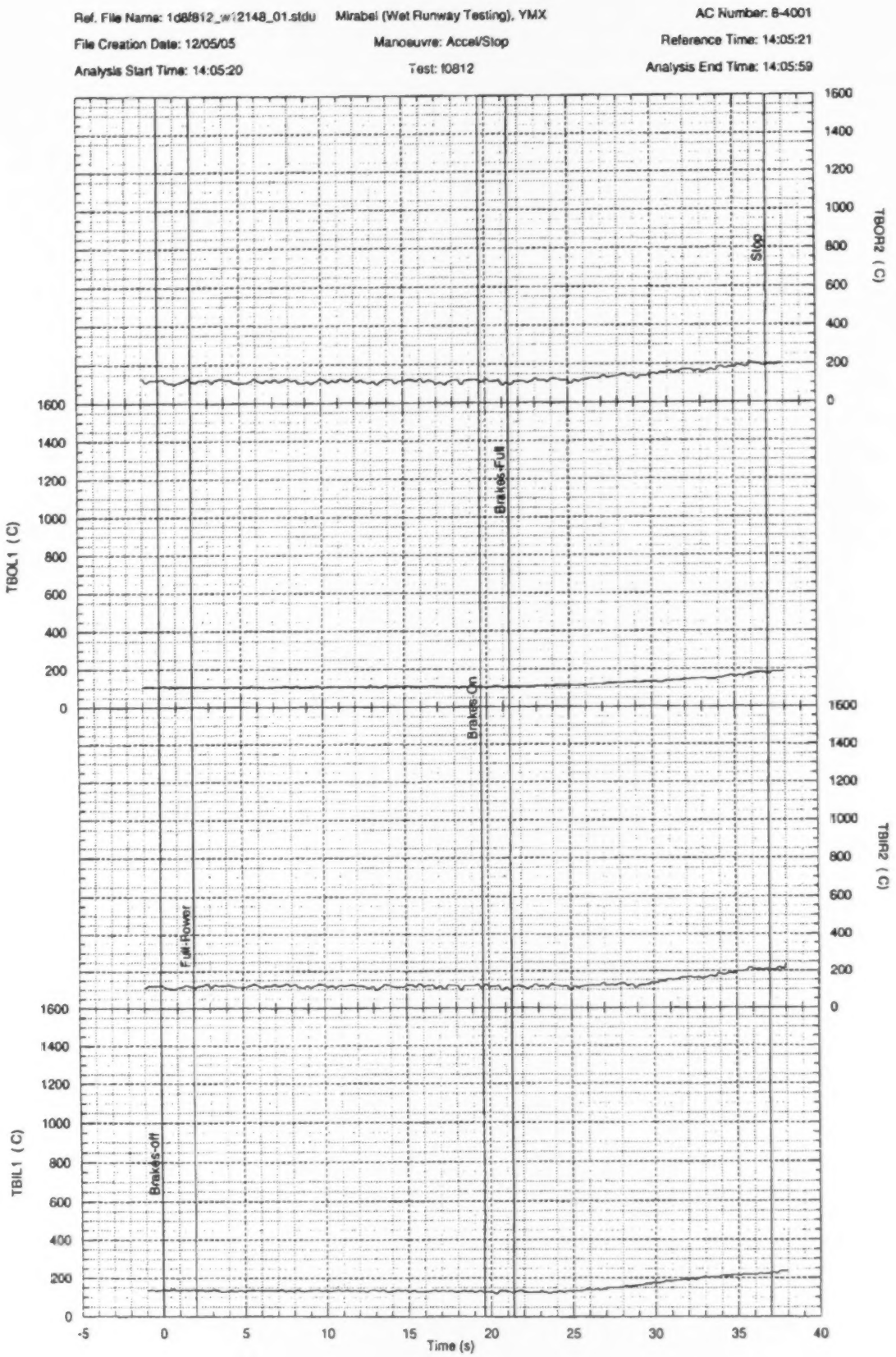

Ref. File Name: 1d8f812_w12148_01.stdu
Mirabel (Wet Runway Testing), YMX
AC Number: 8-4001
File Creation Date: 12/05/05
Manoeuvre: Accel/Stop
Reference Time: 14:05:21
Analysis Start Time: 14:05:20
Test: f0812
Analysis End Time: 14:05:59
ASIFR (deg)
ASOFR (deg)
ASIFL (deg)
ASOFL (deg)
Stop
Brakes-Full
Brakes-On
Full-Power
Brakes-off
Time (s)

Ref. File Name: 1d8f812_w12148_01.stdu | Mirabel (Wet Runway Testing), YMX | AC Number: 8-4001

File Creation Date: 12/05/05 | Manoeuvre: Accel/Stop | Reference Time: 14:05:21

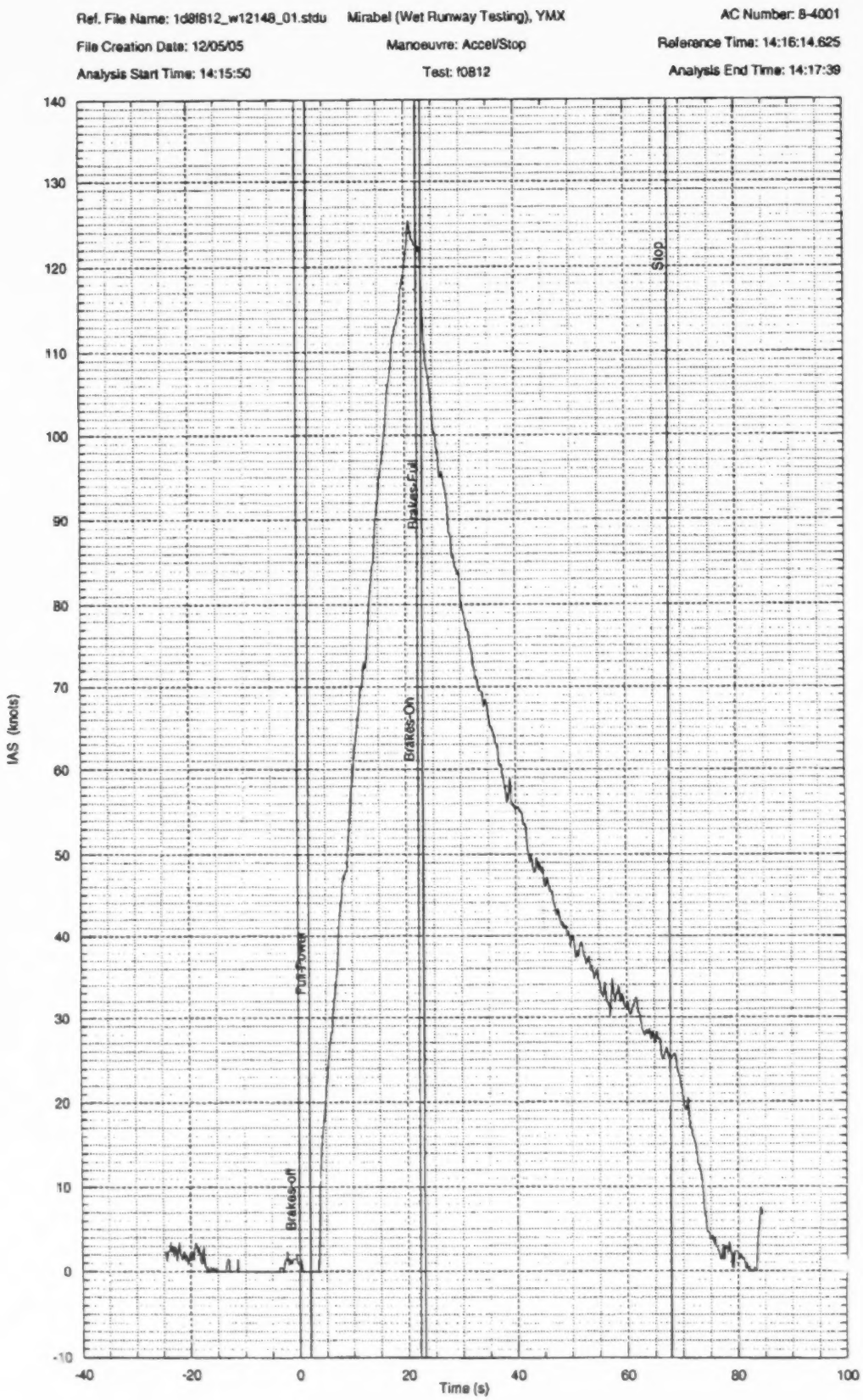
Analysis Start Time: 14:05:20 | Test: f0812 | Analysis End Time: 14:05:59





DAFT version: 2.10
/tmp_mnt/hotfs/flightsci/Flt_Data/4001/t800-t899/t812/TP5.5.plt

Test Point 5.6



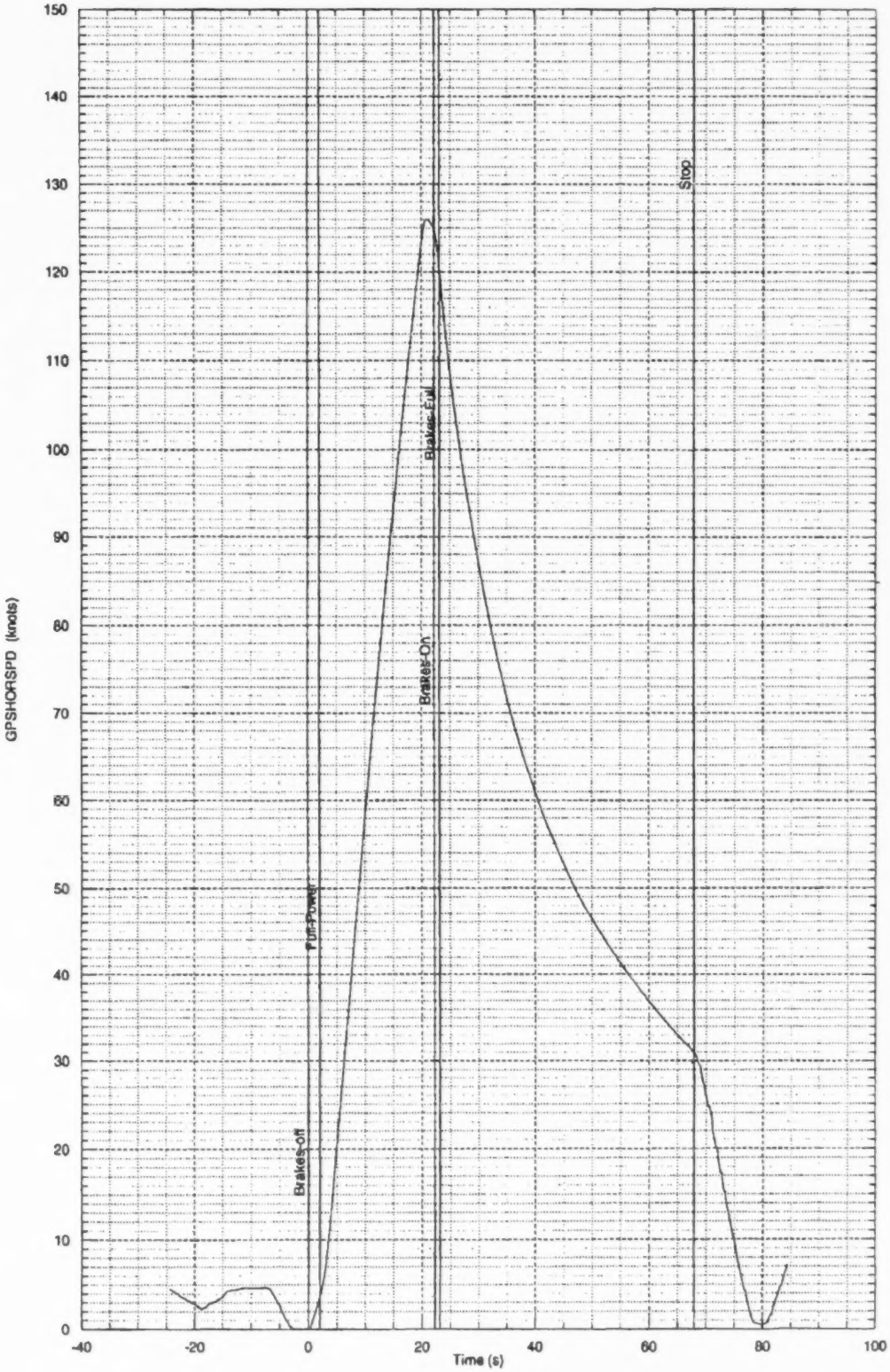
DAFT version: 2.10
/tmp_mnt/ots/flight/sc/Flt_Data/4001/f800-f899/f812/TP5.6.pl

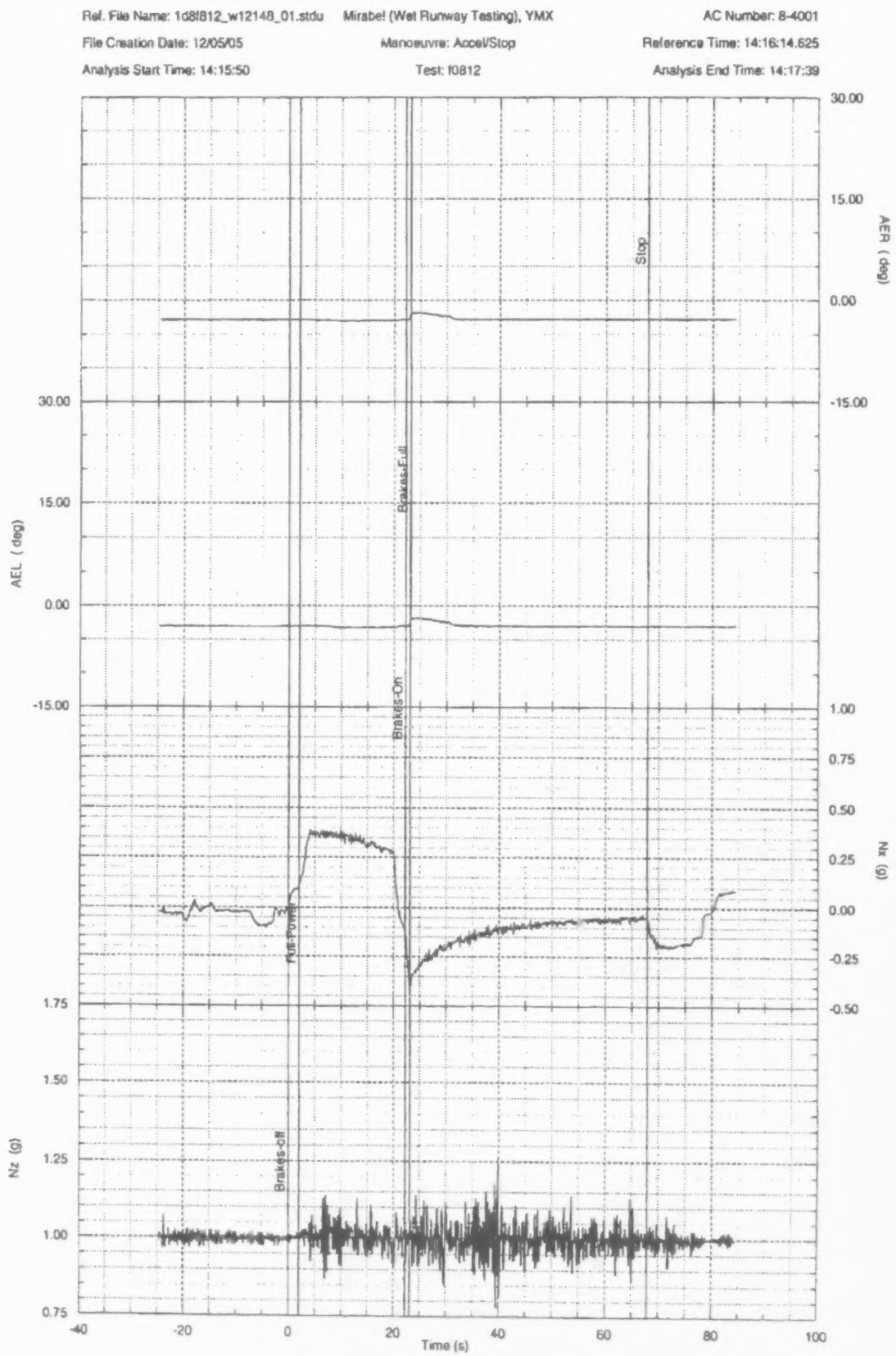
DAFT version: 2.10

Ref. File Name: 1d8f812_w12148_01.stdu Mirabel (Wet Runway Testing), YMX AC Number: 8-4001

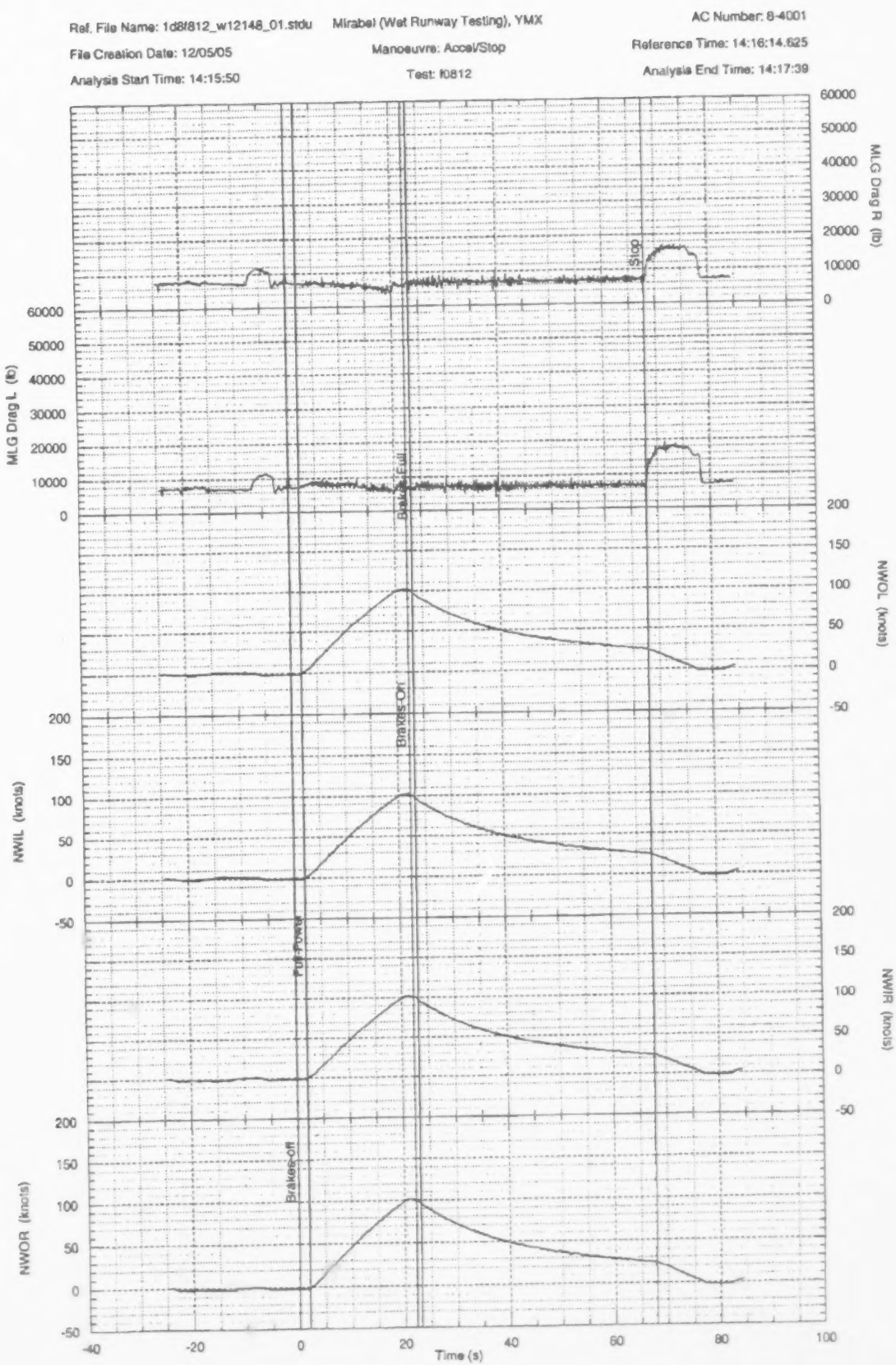
File Creation Date: 12/05/05 Manoeuvre: Accel/Stop Reference Time: 14:16:14.625

Analysis Start Time: 14:15:50 Test: f0812 Analysis End Time: 14:17:39





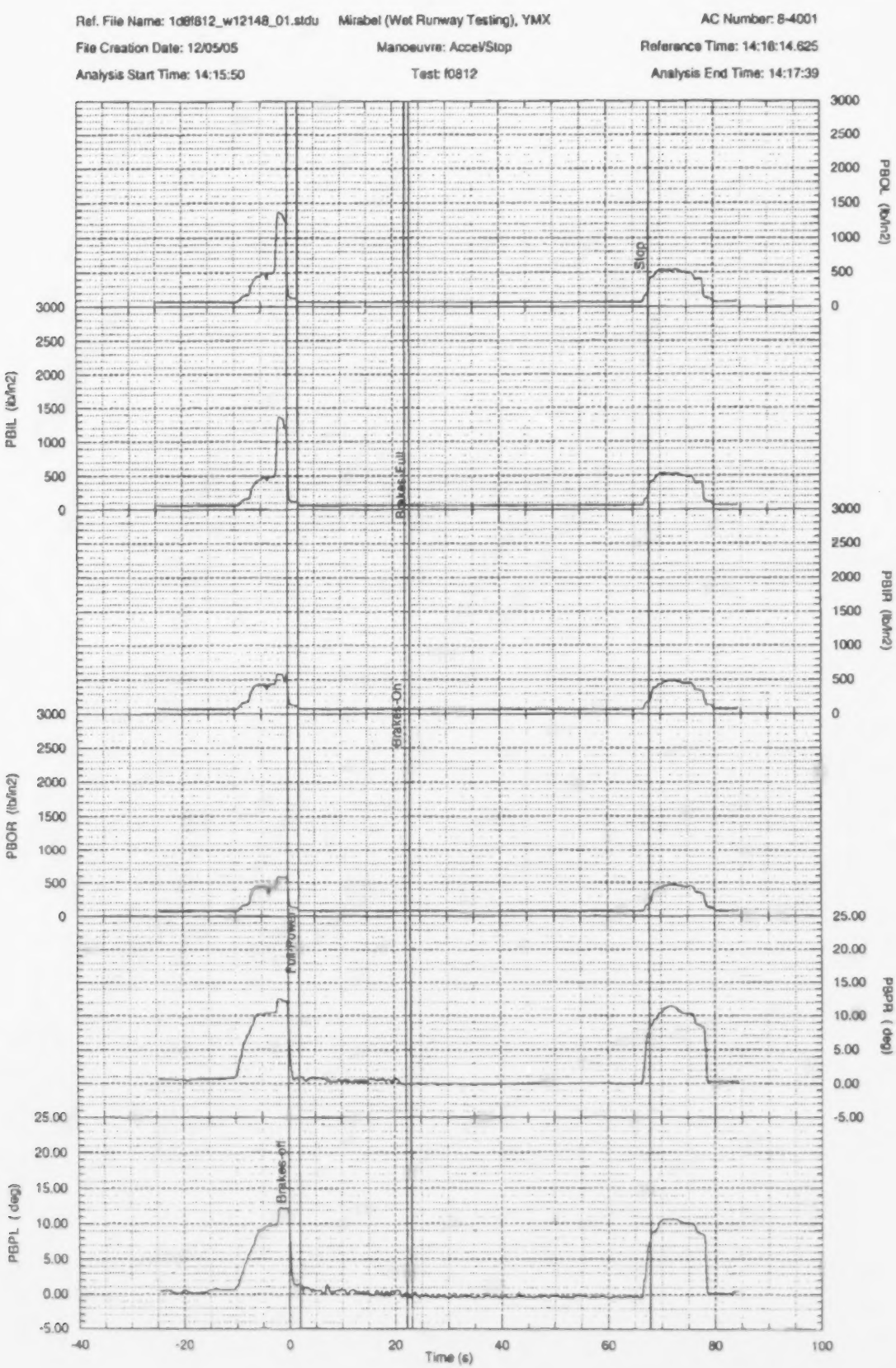
DAFT version: 2.10
/tmp_mnt/vorfs/flightsc/Flt_Data/4001/f800-f899/f812/TPS.6.pl


Ref. File Name: 1d8f812_w12148_01.stdu
Mirabel (Wet Runway Testing), YMX
AC Number: 8-4001
File Creation Date: 12/05/05
Manoeuvre: Accel/Stop
Reference Time: 14:16:14.625
Analysis Start Time: 14:15:50
Test: f0812
Analysis End Time: 14:17:39
MLG Drag L (lb)
MLG Drag R (lb)
NWOL (knots)
NWIL (knots)
NWIR (knots)
NWOR (knots)
Stop
Brakes-Off
Full Power
Brakes-on
Time (s)

Ref. File Name: 1d8f812_w12148_01.stdu Mirabel (Wet Runway Testing), YMX AC Number: 8-4001

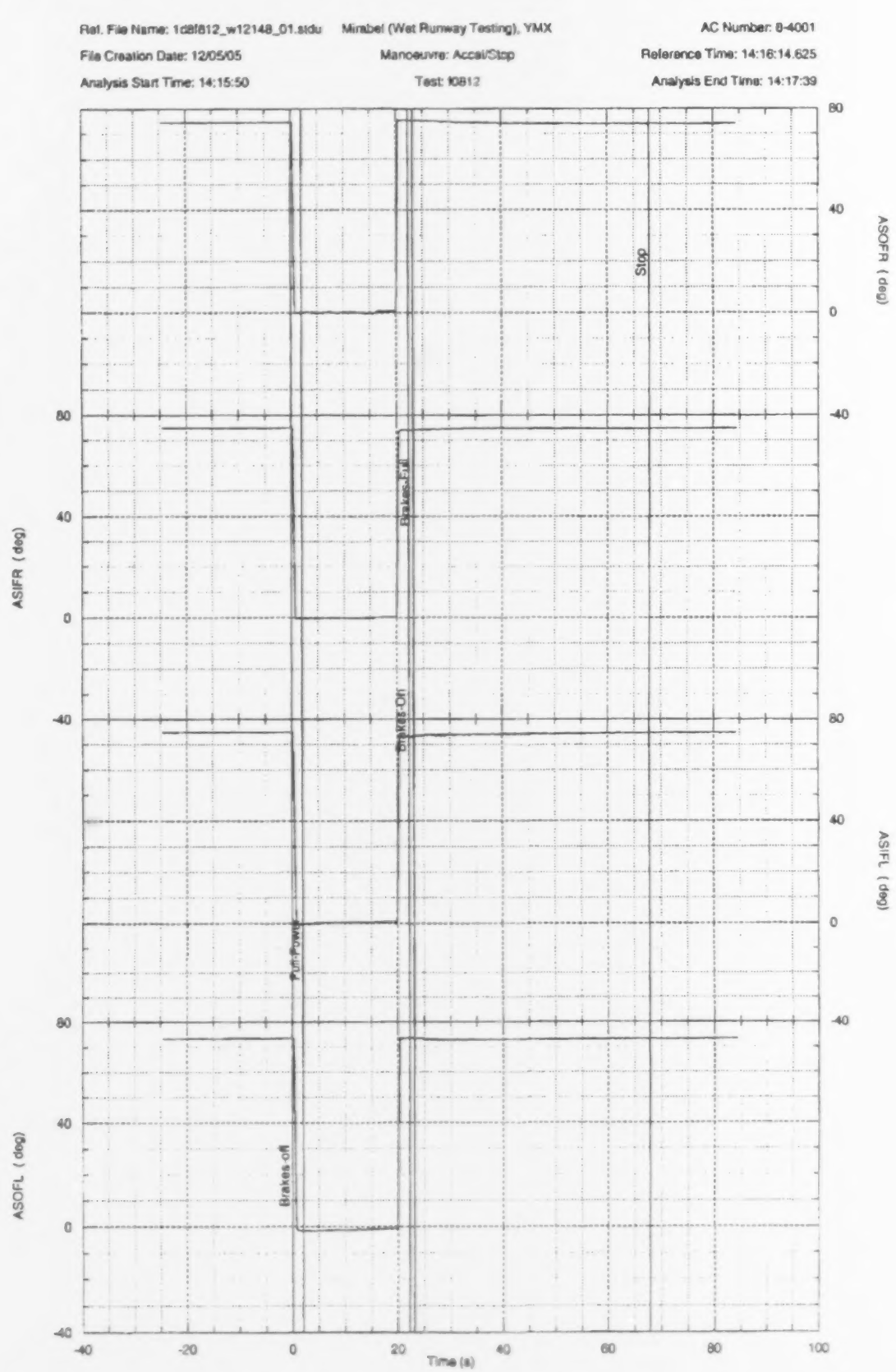
File Creation Date: 12/05/05 Manoeuvre: Accel/Stop Reference Time: 14:16:14.625

Analysis Start Time: 14:15:50 Test: f0812 Analysis End Time: 14:17:39

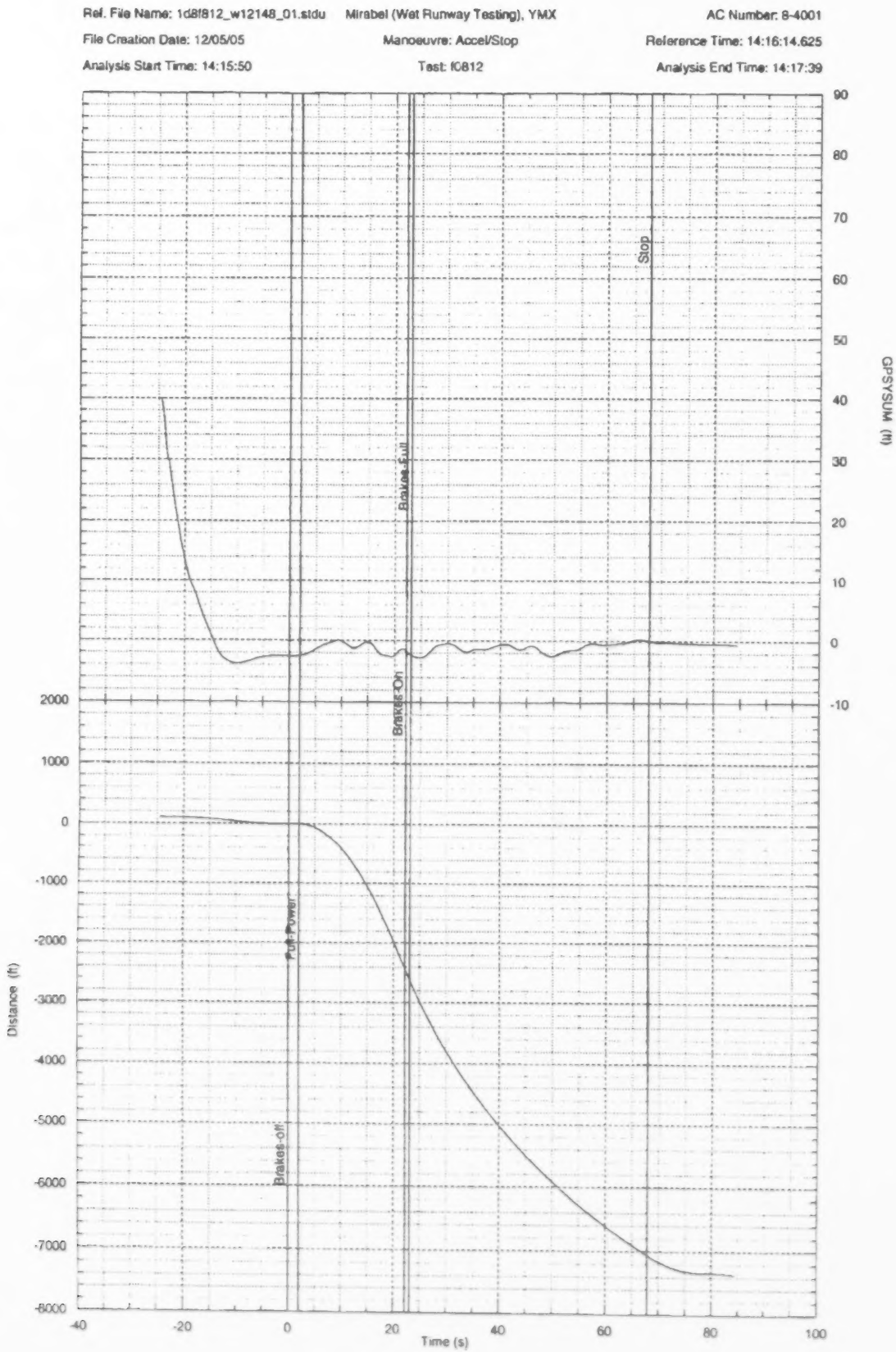


DAFT version: 2.10

/tmp_mnt/forfs/flightsc/Fil_Data/4001/f800-f899/f812/TP5.6.plt



DAFT version: 2.10



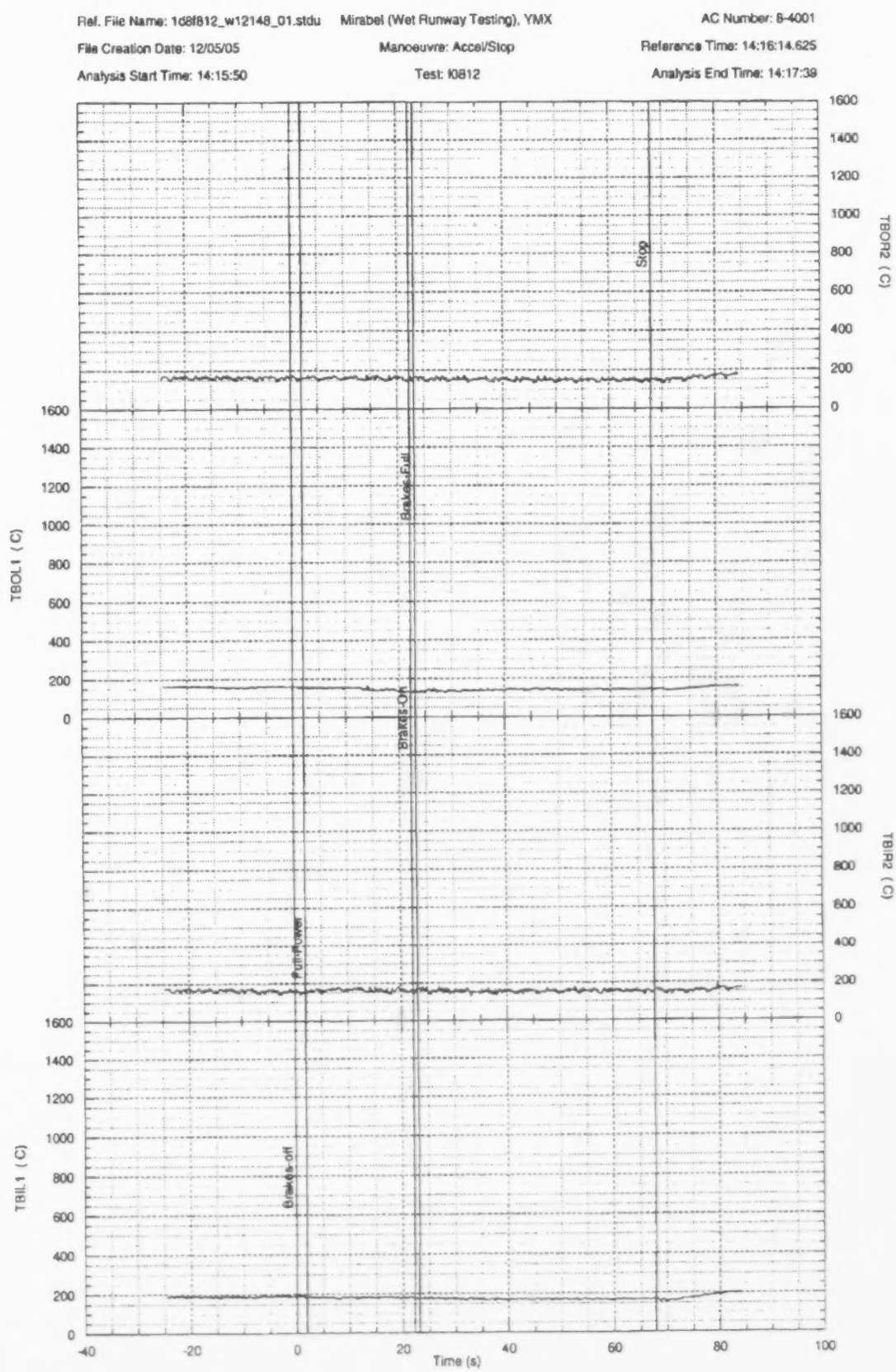
DAFT version: 2.10

/tmp_mnt/for/flightsc/Flt_Data/4001/f800-1899/f812/TP5 6.plt

Ref. File Name: 1d8f812_w12148_01.stdu Mirabel (Wet Runway Testing), YMX AC Number: 8-4001

File Creation Date: 12/05/05 Manoeuvre: Accel/Stop Reference Time: 14:16:14.625

Analysis Start Time: 14:15:50 Test: I0812 Analysis End Time: 14:17:39



/tmp_mnt/forts/flightsc/Flt_Data/4001/8000-8999/812/1P5.ai.plt

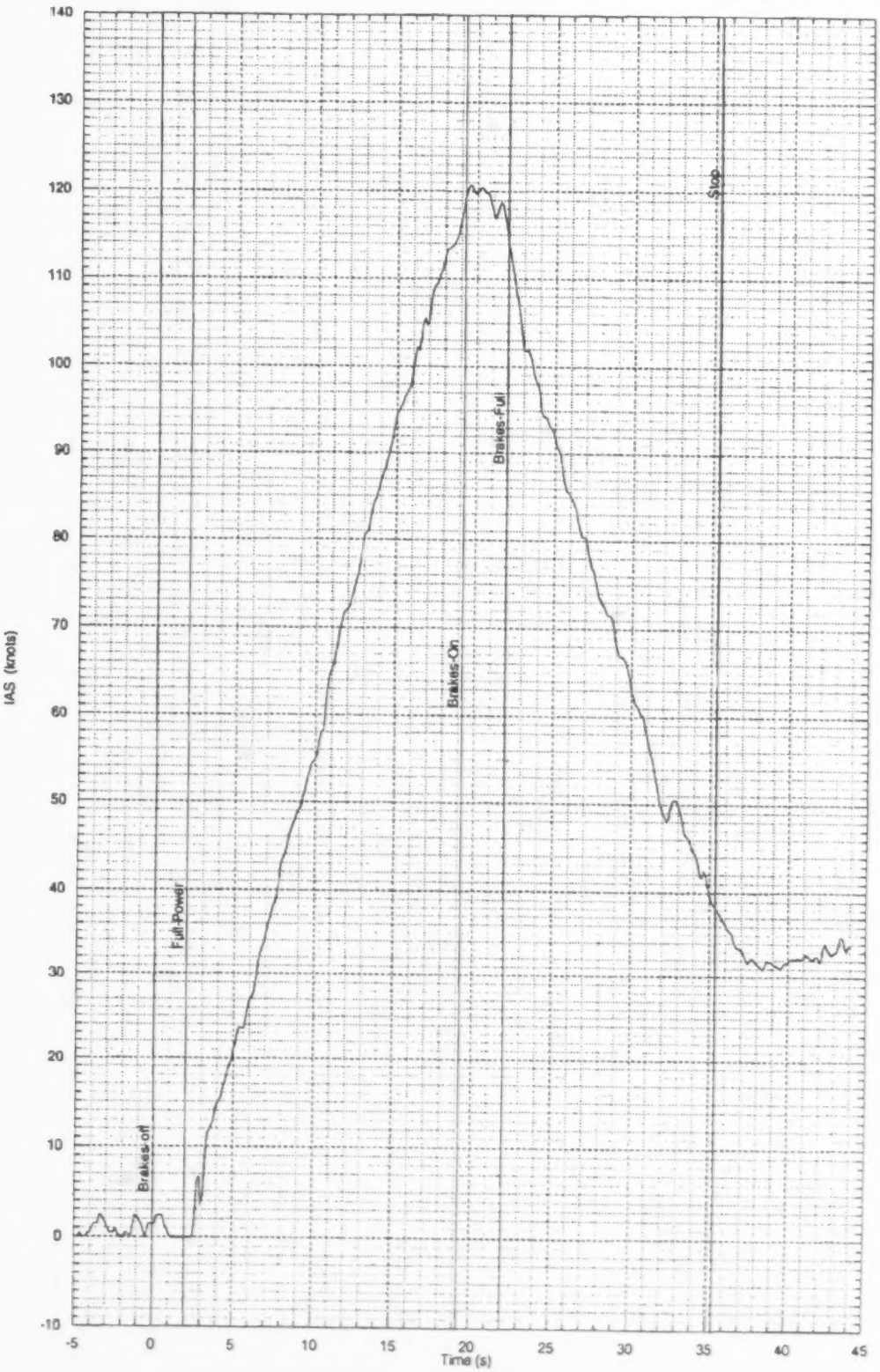
Test Point 5.7

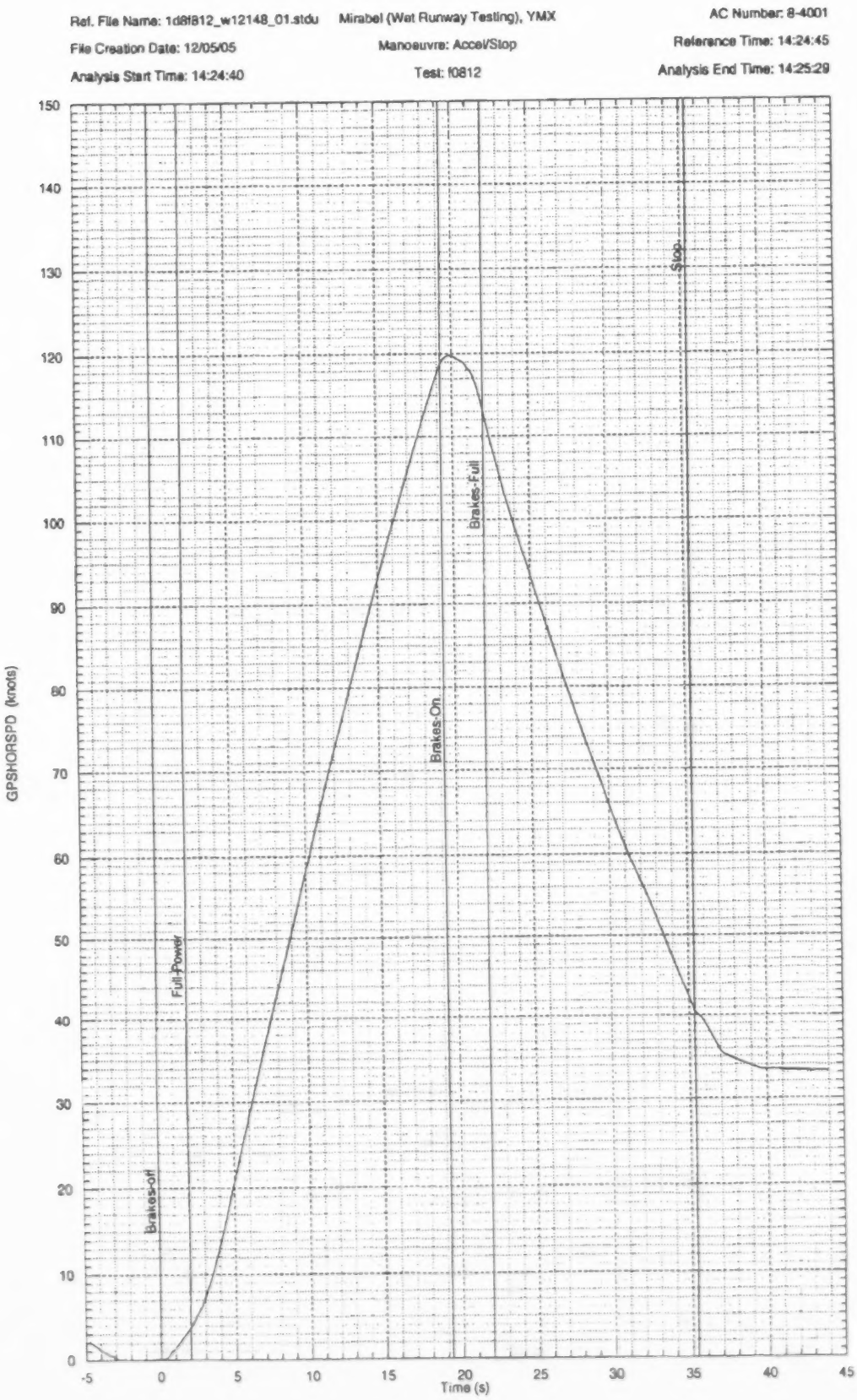
DAFT version: 2.10

Ref. File Name: 1d6f812_w12148_01.stdu Mirabel (Wet Runway Testing), YMX AC Number: 8-4001

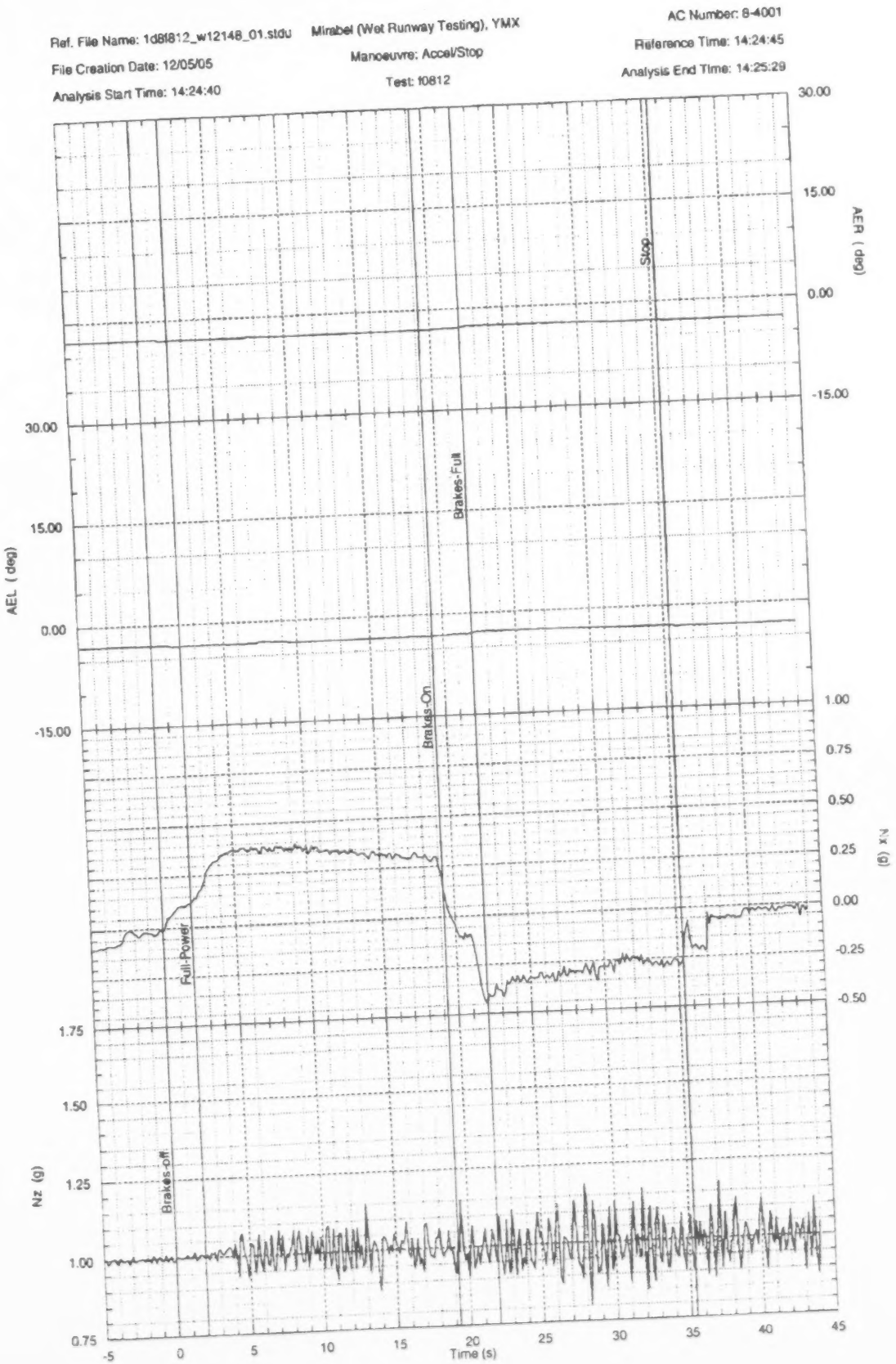
File Creation Date: 12/05/05 Manoeuvre: Accel/Stop Reference Time: 14:24:45

Analysis Start Time: 14:24:40 Test: f0812 Analysis End Time: 14:25:29





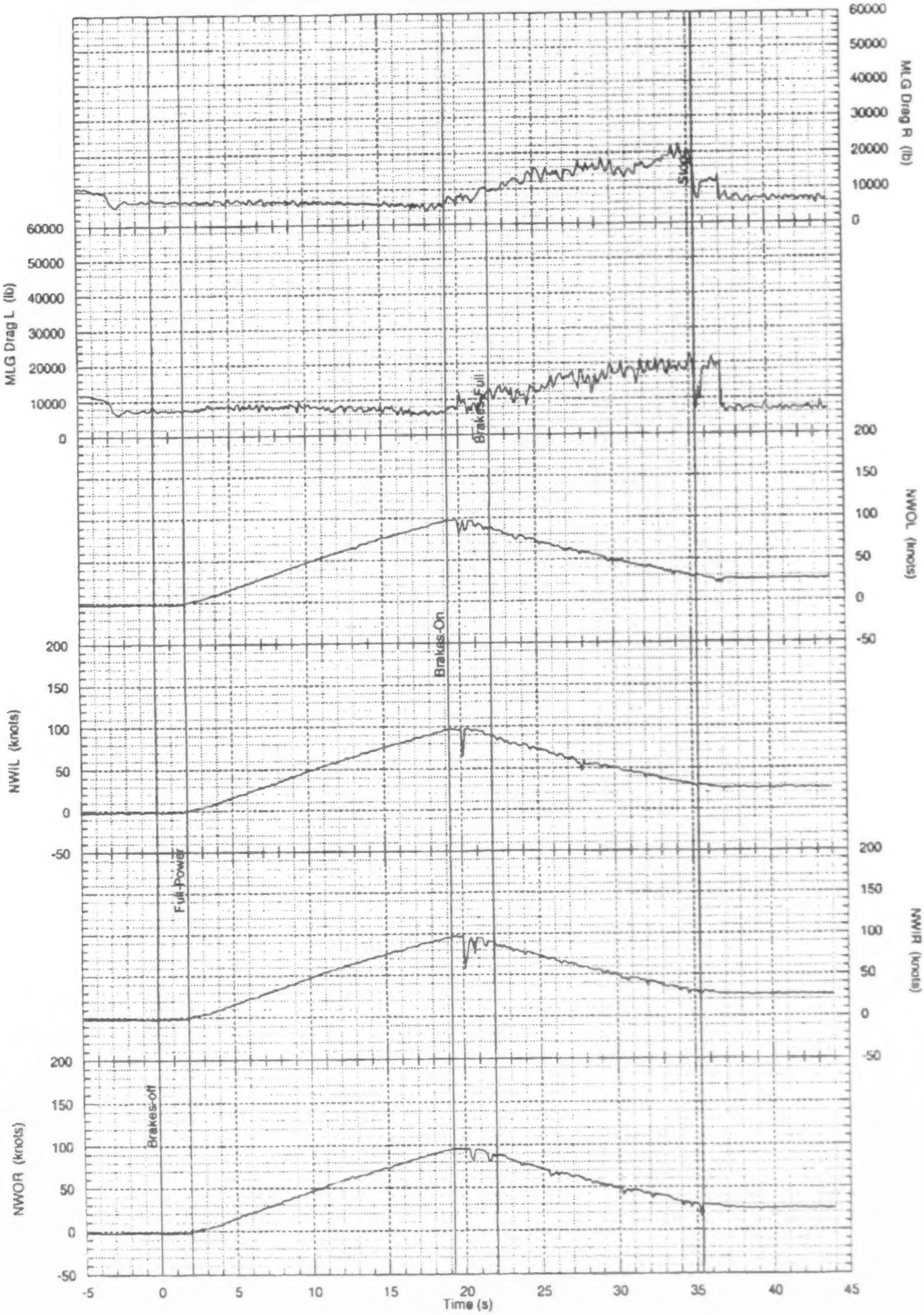
DAFT version: 2.10
/tmp_mnt/tofs/flights/c/Flt_Data/4001/f800-f899/f812/TP5.7.plt


Ref. File Name: 1d81812_w12148_01.std
File Creation Date: 12/05/05
Analysis Start Time: 14:24:40
Mirabel (Wet Runway Testing), YMX
Manoeuvre: Accel/Stop
Test: t0812
AC Number: 8-4001
Reference Time: 14:24:45
Analysis End Time: 14:25:29
Stop
Brakes-Full
Brakes-On
Full-Power
Brakes-off
AEL (deg)
AER (deg)
Nz (g)
Nx (g)
Time (s)
30.00
15.00
0.00
-15.00
1.00
0.75
0.50
0.25
-0.25
-0.50
1.75
1.50
1.25
1.00
0.75
-5
0
5
10
15
20
25
30
35
40
45

Ref. File Name: 1d8f812_w12148_01.stdu | Mirabel (Wet Runway Testing), YMX | AC Number: 8-4001

File Creation Date: 12/05/05 | Manoeuvre: Accel/Stop | Reference Time: 14:24:45

Analysis Start Time: 14:24:40 | Test: f0812 | Analysis End Time: 14:25:29



DAFT version: 2.10

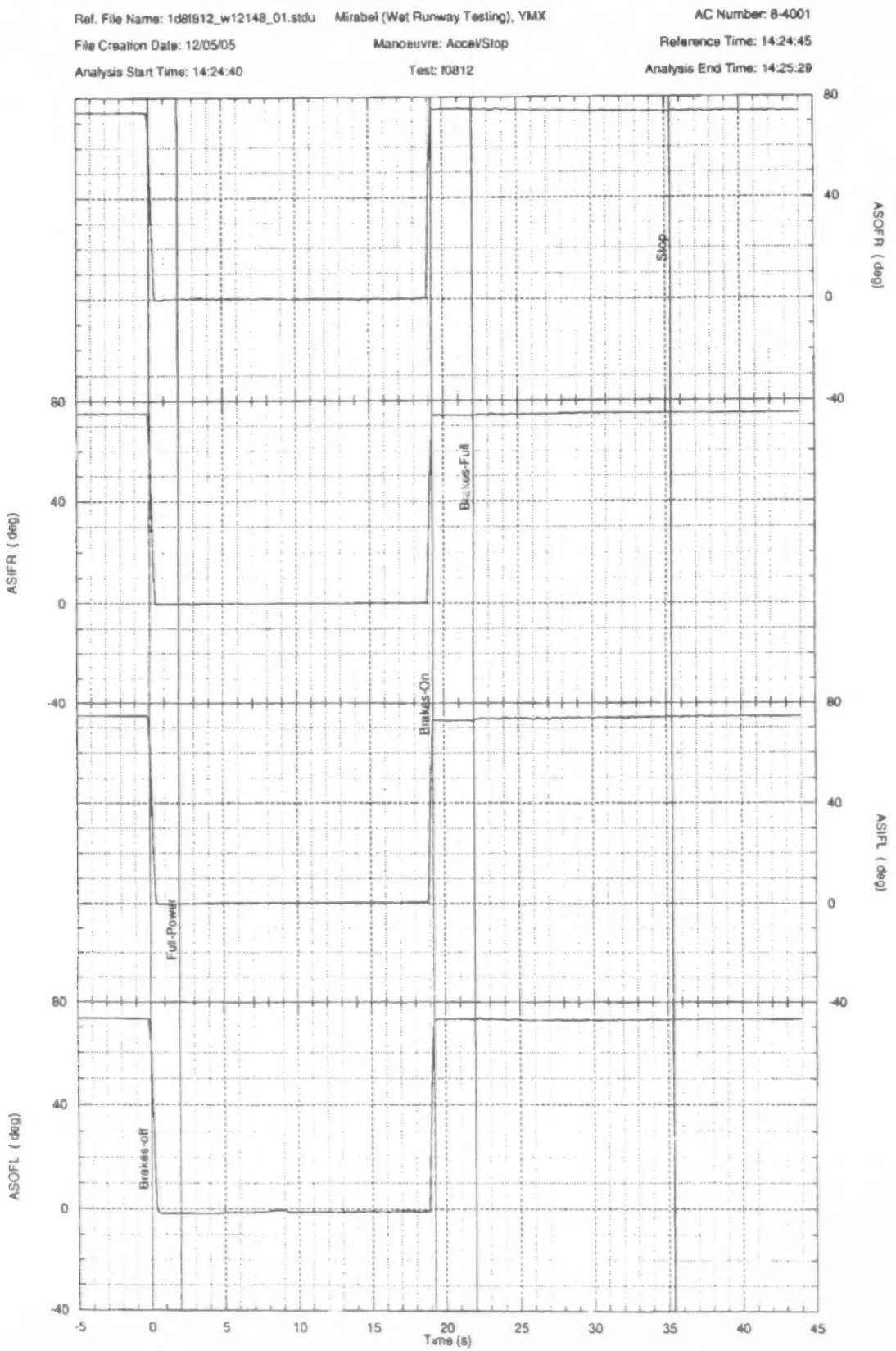
/tmp_mnt/orfs/flightsc/Flt_Data/4001/800-899/812/TPS.7.plt

Ref. File Name: 1d8f812_w12148_01.stdu
Mirabel (Wet Runway Testing), YMX
AC Number: 8-4001
File Creation Date: 12/05/05
Manoeuvre: Accel/Stop
Reference Time: 14:24:45
Analysis Start Time: 14:24:40
Test: f0812
Analysis End Time: 14:25:29
PBOL (lb/in2)
PBIL (lb/in2)
PBIR (lb/in2)
PBOR (lb/in2)
PBPR (deg)
PBPL (deg)
Stop
Brakes-Full
Brakes-Off
F.J.R.Power
Brakes-off
Time (s)

Ref. File Name: 1d8f812_w12148_01.stdu Mirabel (Wet Runway Testing), YMX AC Number: 8-4001

File Creation Date: 12/05/05 Manoeuvre: Accel/Stop Reference Time: 14:24:45

Analysis Start Time: 14:24:40 Test: f0812 Analysis End Time: 14:25:29



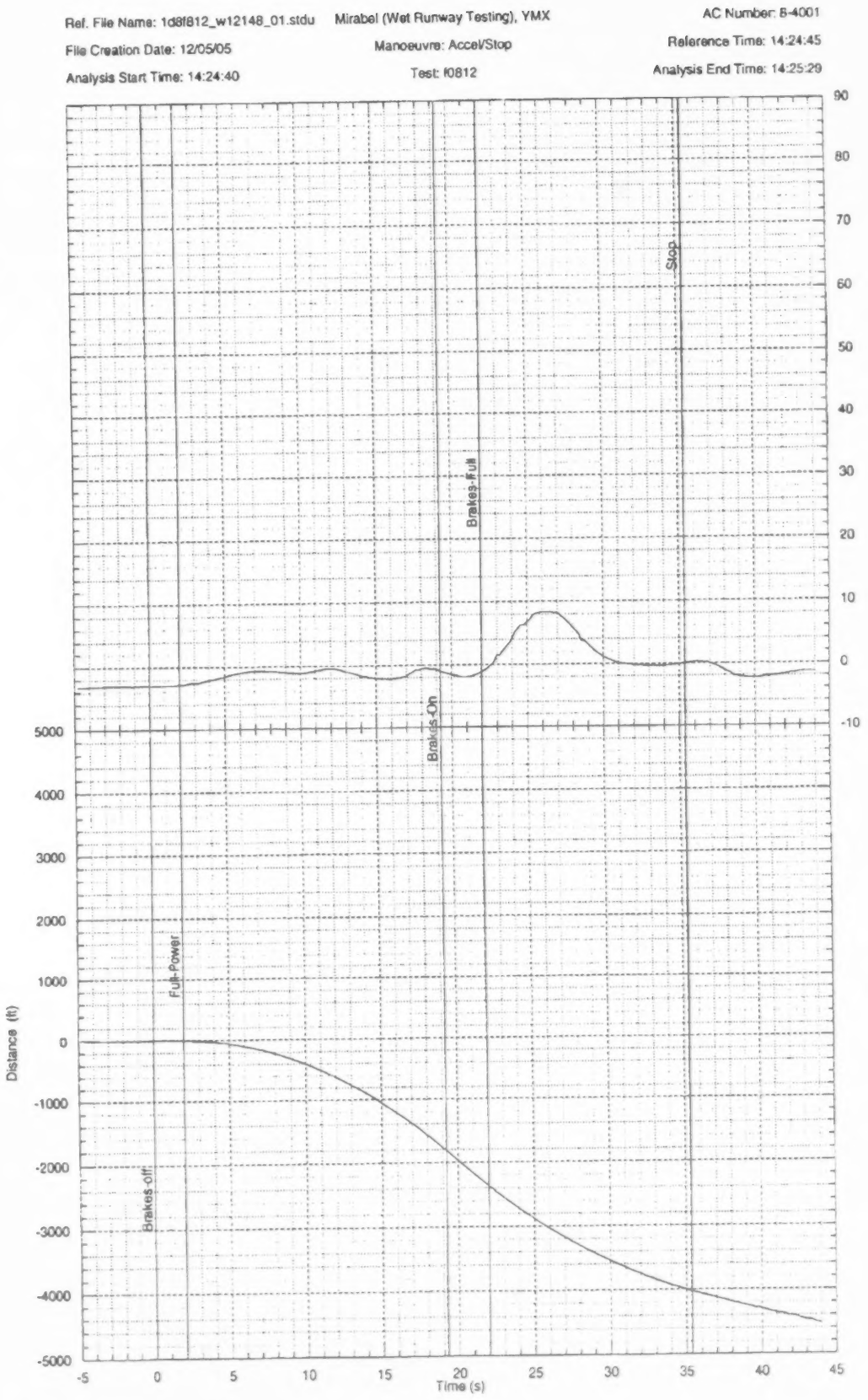
DAFT version: 2.10

/tmp_mnt/forfs/flightsc/Flt_Data/4001/f800-f899/f812/TP5.7.plt

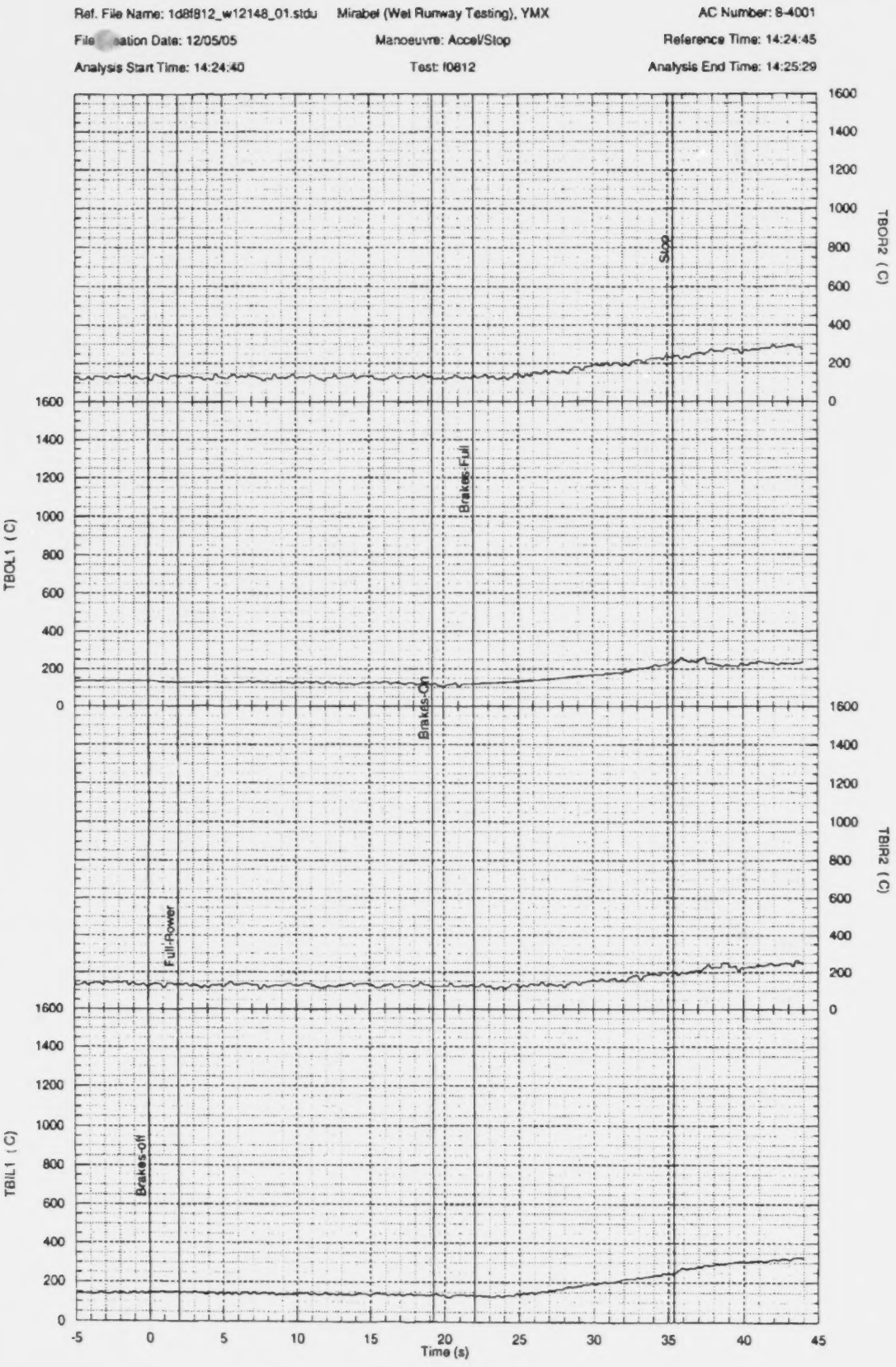
Ref. File Name: 1d8f812_w12148_01.stdu
File Creation Date: 12/05/05
Analysis Start Time: 14:24:40

Mirabel (Wet Runway Testing), YMX
Manoeuvre: Accel/Stop
Test: f0812

AC Number: 8-4001
Reference Time: 14:24:45
Analysis End Time: 14:25:29

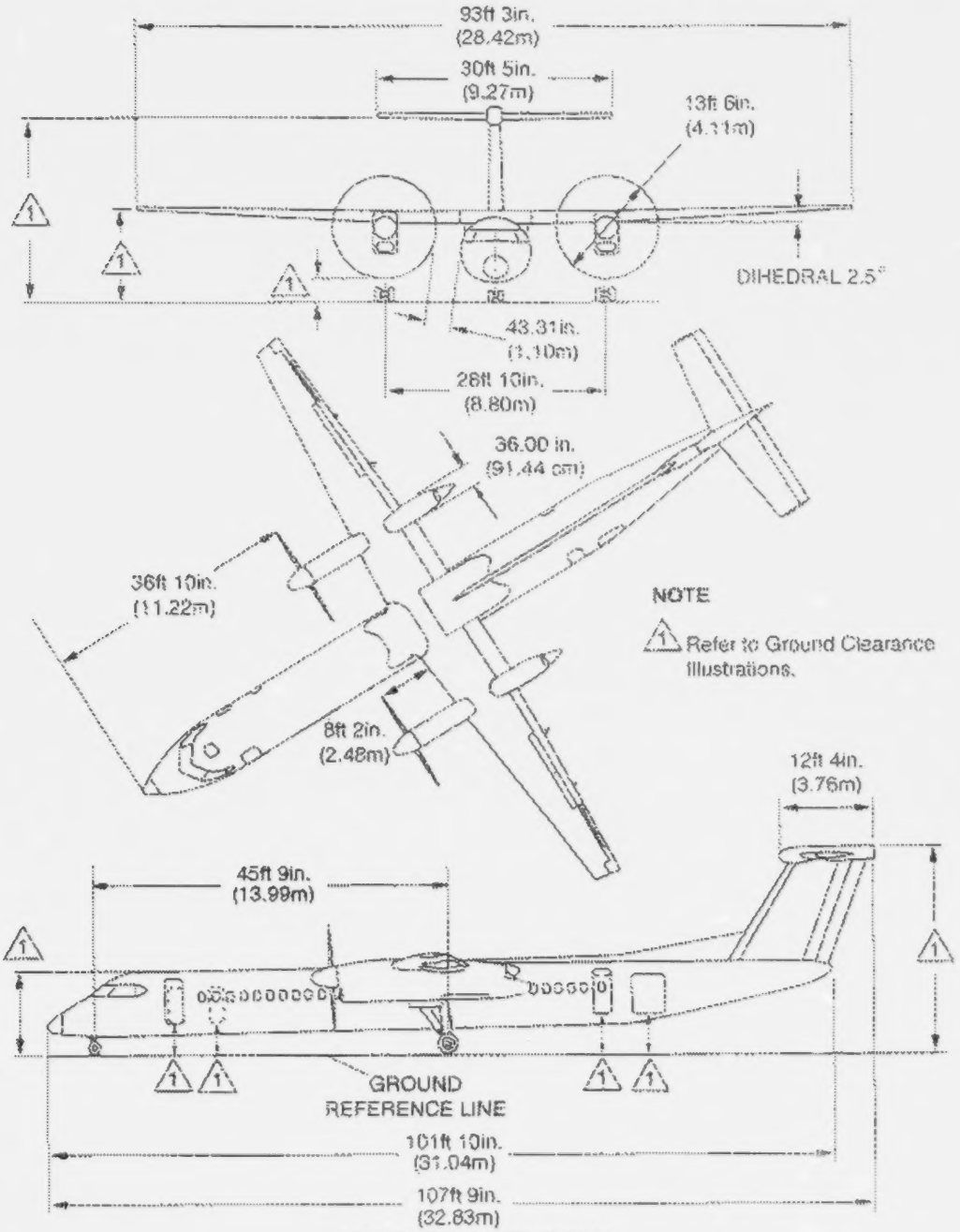


/tmp_mnt/forts/flightsc/Flt_Data/4001/1800-1899/1812/TP5.7.plt



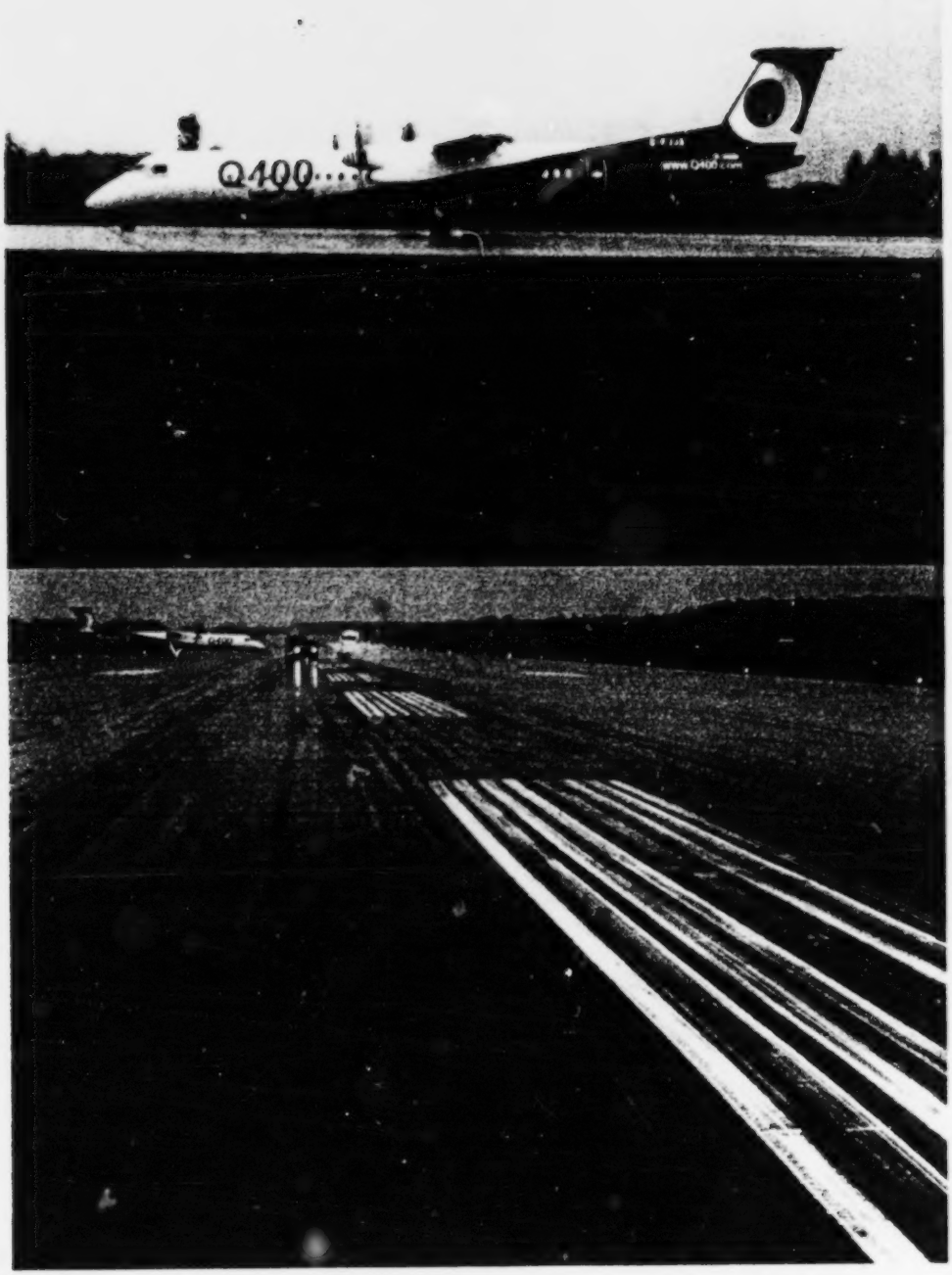
DAFT version: 2.10
/tmp_mnt/vol/flightsc/Flt_Data/4001/f800-f899/f812/TPs.7.plt

APPENDIX C – Dash 8 Flight Test Aircraft 4001 Specifications

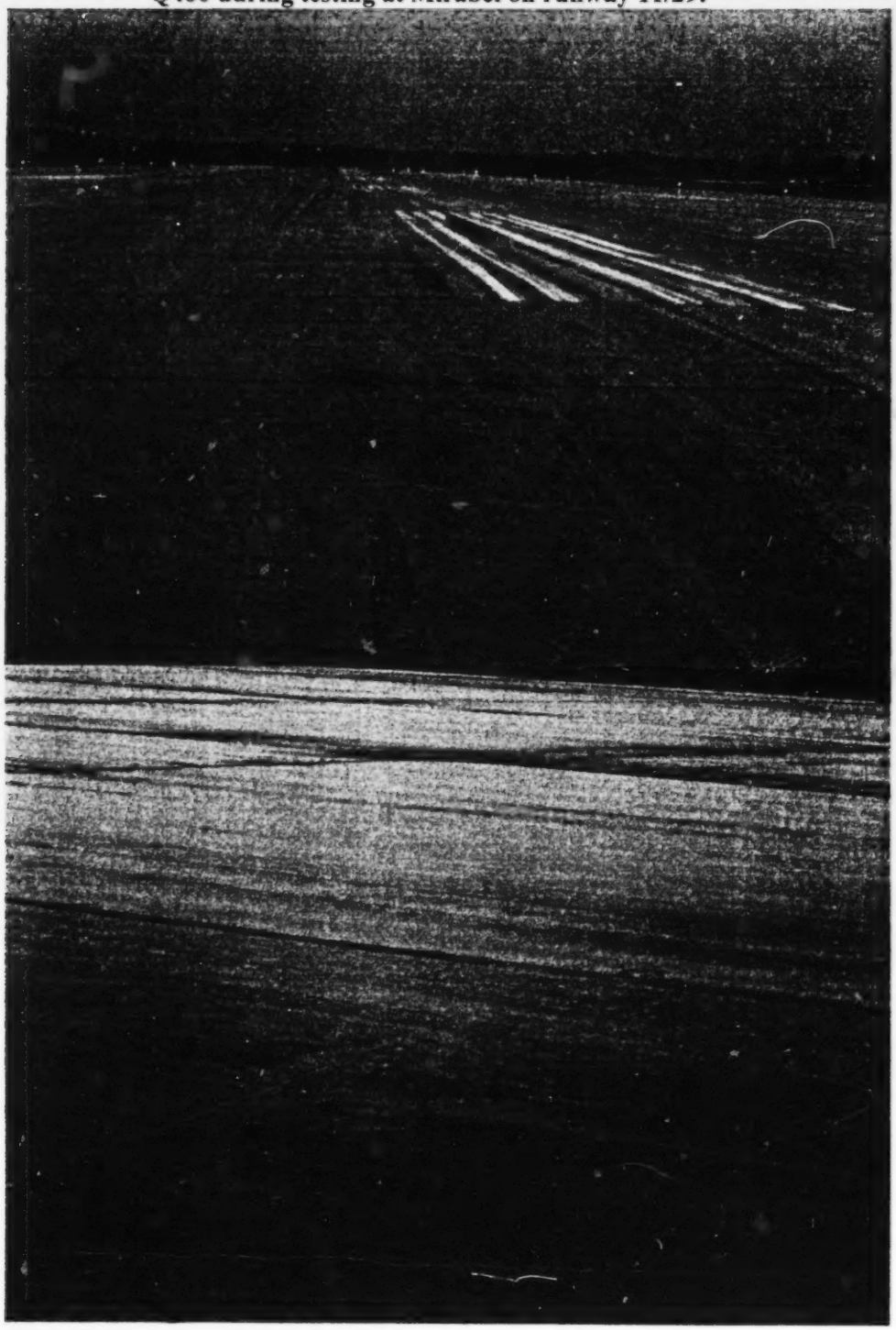


AIRCRAFT DIMENSIONS

APPENDIX D – Q400 Wet Runway Testing Pictures
Q400 during testing at Mirabel on runway 11/29:



APPENDIX D – Q400 Wet Runway Testing Pictures
Q400 during testing at Mirabel on runway 11/29:



APPENDIX E - SFT Friction Data and Landing Distance Factors

SFT friction measurements were taken before and after each aircraft landing and accel-stop test point. A summary of the SFT data used for each test point is shown in Table E-1, with the SFT data shown in the following charts, the data being an average of the TC SFT data and the Tradewind SFT data. For test points 5.1 and 5.5, too much time had elapsed between the SFT runs before the aircraft test and the aircraft test. Therefore, only the SFT data from after the aircraft test is included in the charts for these two test points. Also shown on the charts is the aircraft measured runway friction as a ratio of the FAR wet runway model. A friction ratio was plotted in this Appendix in order to isolate runway surface effects from ground speed effects. The aircraft measured runway friction for each test point and the FAR wet runway model are shown against ground speed in Appendix A.

The SFT data with the aircraft measured runway friction ratio are plotted against runway distance. The distance plotted in the time histories of Appendix B are also DGPS distances, but the distances are relative to time equal to zero. For accel-stops the start of the test is set as time equal to zero, and for landing the end of the test is set as time equal to zero.

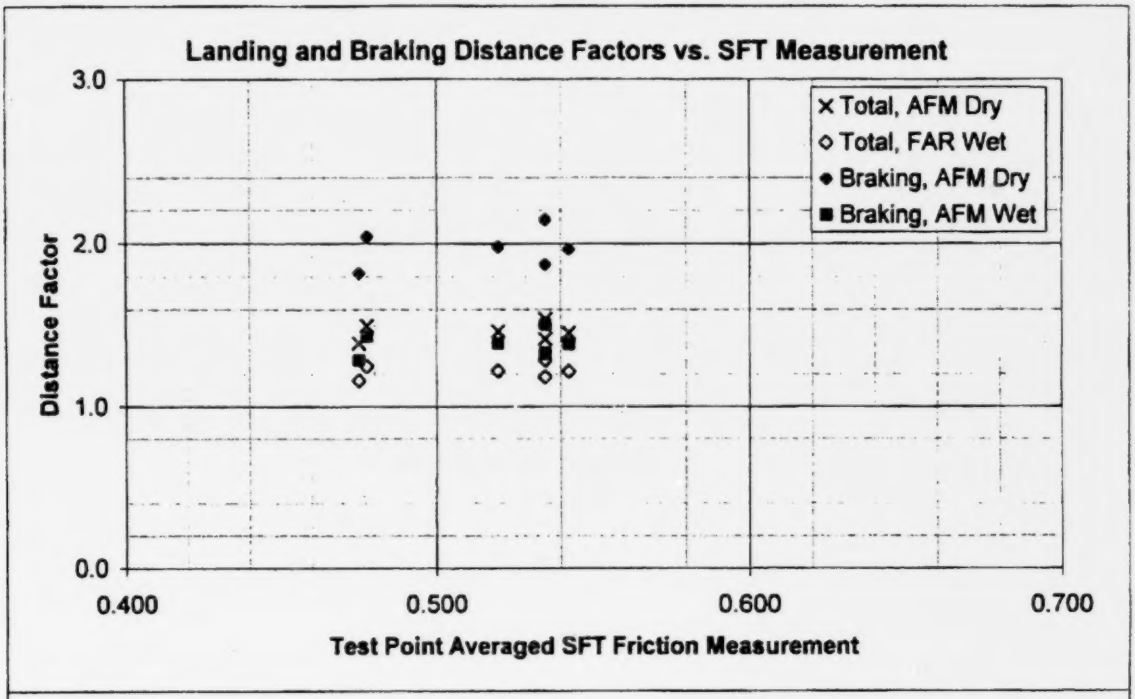
The SFT test data was plotted against runway distance, using the test cone locations to align the SFT distances with runway distances. Cones were set out on the runway to mark the location of the test sections. One cone marking the start of the test section, and one marking the end of the test section. The cone positions were recorded in DGPS distance in the flight test logs. The DGPS cone positions of the start and end of the test sections were recorded as 1483 ft and 3793 ft for runway 11 respectively, and 9382 ft and 6081 ft for runway 29 respectively. To align the SFT distance to the runway distance, the start of the SFT distance was set to the DGPS location of the start cone. Therefore, for runway 11, the SFT distance 5+500 m was set to 1483 ft, and for runway 29, the SFT distance 6+800 m was set to 9382 ft. The remaining distances are treated as increments to the starting distance, with the SFT data evaluated at the mid-point of the SFT distances. The Transport Canada SFT data and Tradewind SFT data is shown in Table E2.

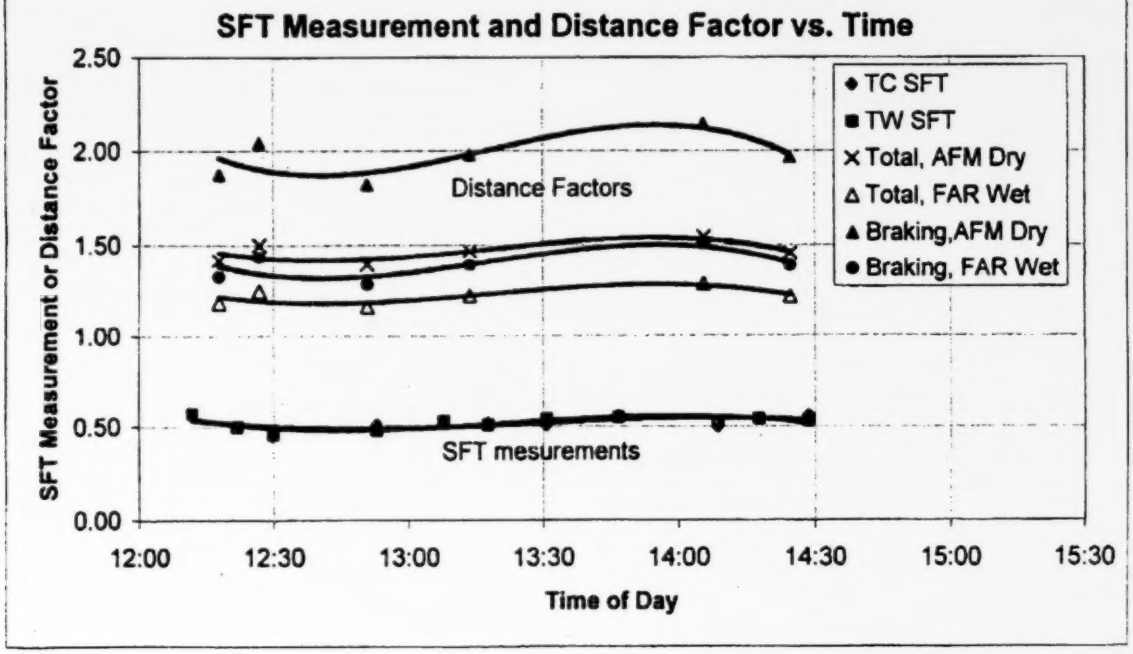
Total landing distances and braking distances were calculated at test conditions for each test point using the AFM dry runway model, the FAR wet runway mu model and the Mirabel runway wet runway friction measured for the particular test point. The distances calculated are shown in Table E-3, with the corresponding Mirabel runway distance factors summarized in TableE-1.

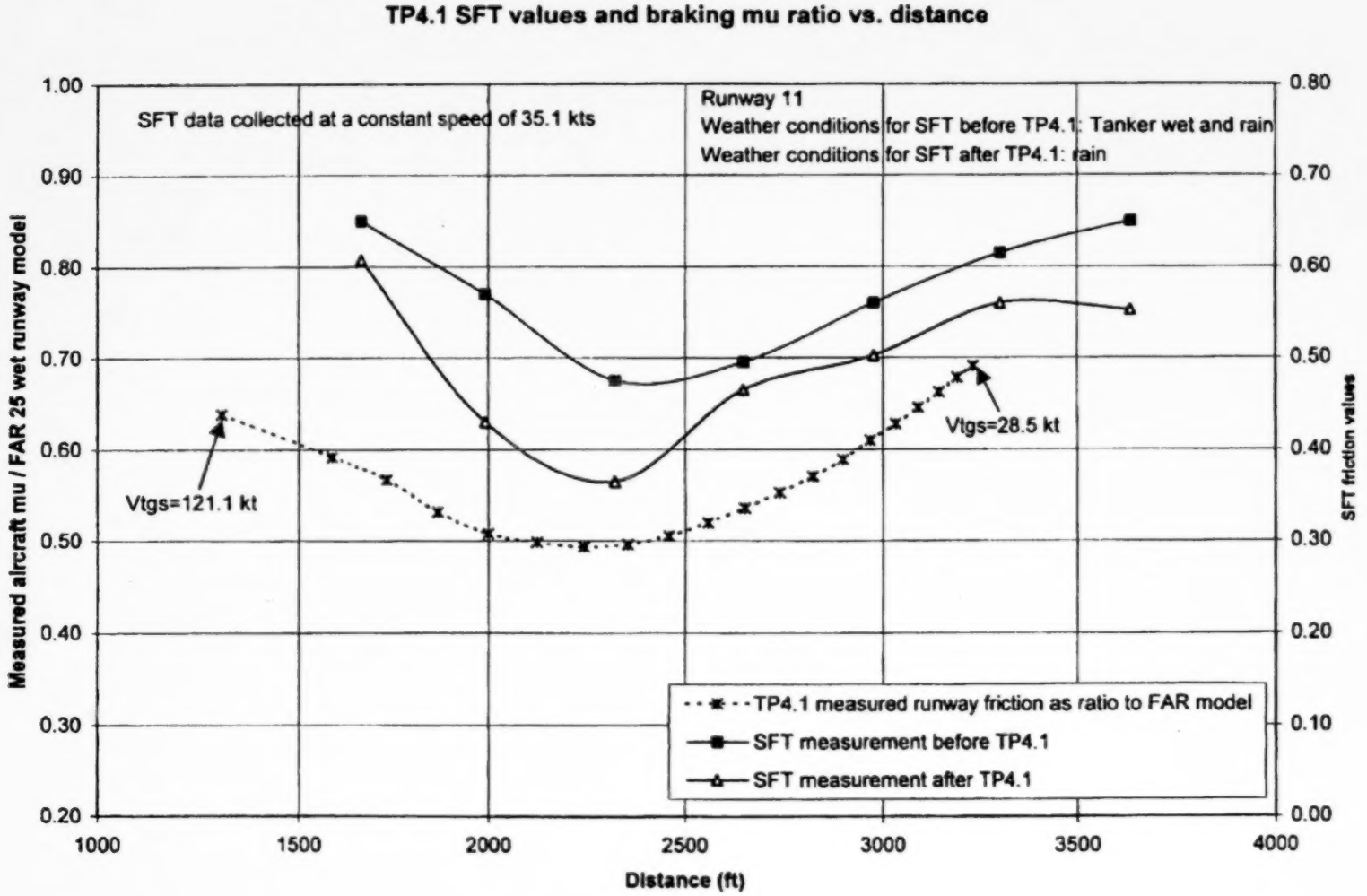
Table E-1: Landing and Braking Distance Factors for Mirabel Wet Runway and Summary of SFT Points

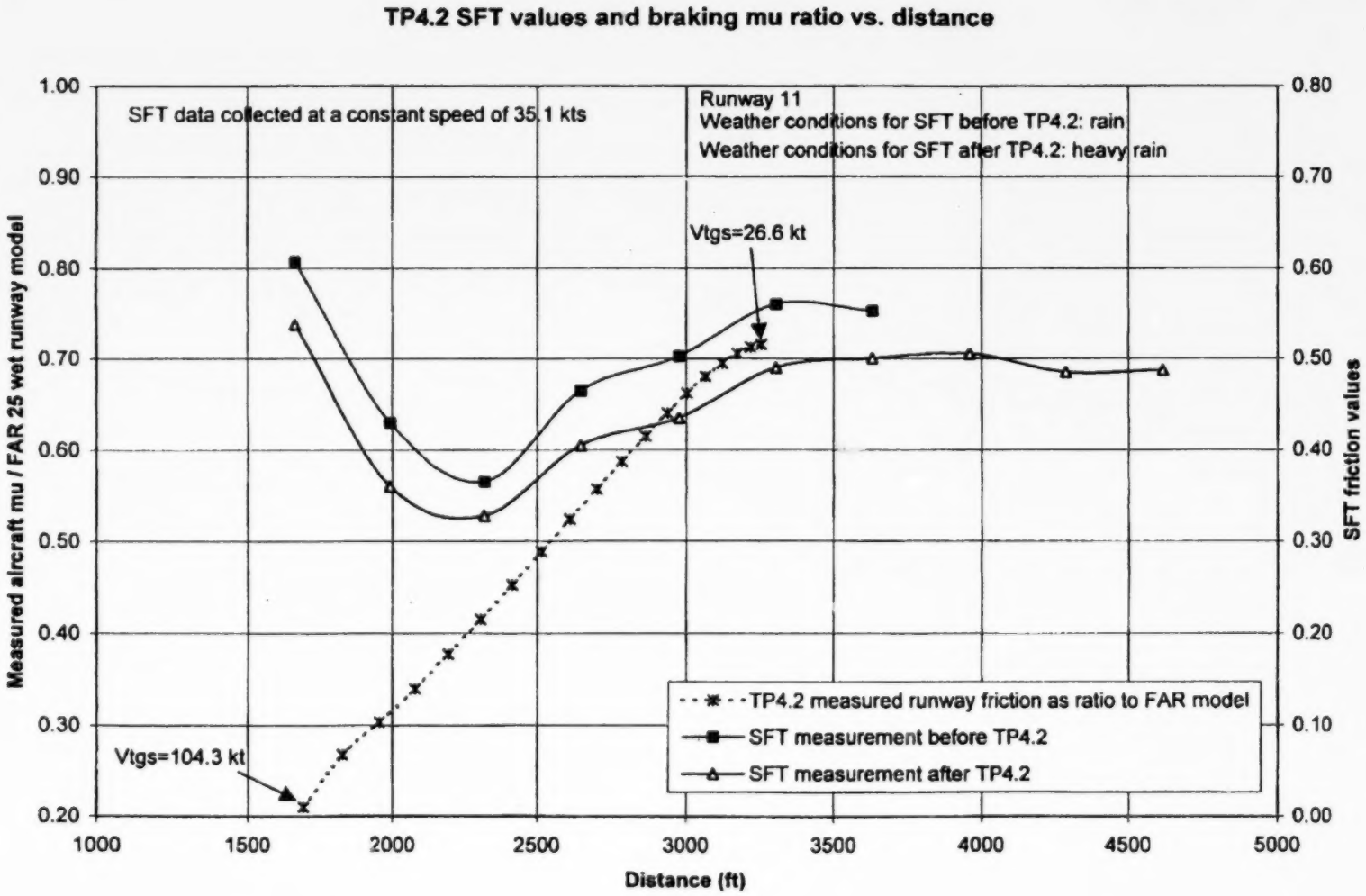
Test Point	Aircraft Test Run Time	Total Landing Distance Factor On AFM Dry Runway	Total Landing Distance Factor On FAR Wet Runway	Braking Distance Factor On Dry Runway	Braking Distance Factor On FAR Wet Runway	SFT Run Start Times	Runway	Transport Canada SFT Average Friction Measurement	Tradewind SFT Average Friction Measurement
						12:12	11	0.57	0.57
4.1	12:18	1.416	1.182	1.875	1.325				
						12:22	11	0.50	0.50
4.2	12:27	1.500	1.247	2.041	1.434				
						12:30	11	0.45	0.46
5.1	12:51	1.390	1.160	1.820	1.284				
						12:53	11	0.51	0.48
						13:08	29	0.52	0.53
5.2	13:14	1.466	1.219	1.980	1.389				
						13:18	29	0.52	0.51
5.3	13:28								
						13:31	29	0.51	0.54
5.4	13:45								
						13:47	29	0.56	0.55
5.5	14:06	1.542	1.285	2.145	1.507				
						14:09	29	0.50	0.53
5.6	14:16								
						14:18	29	0.54	0.54
5.7	14:25	1.456	1.216	1.967	1.386				
						14:29	29	0.56	0.53

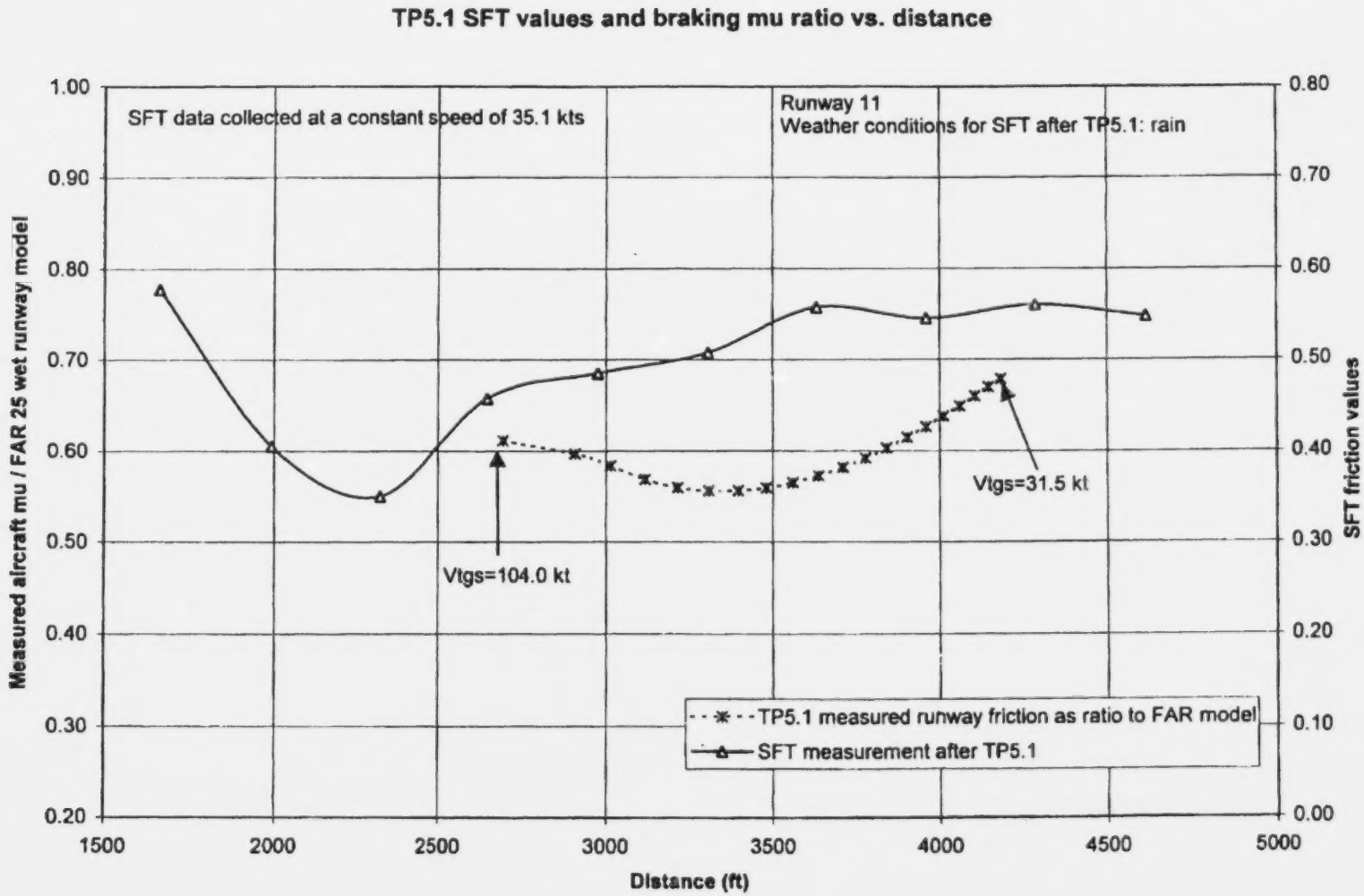
Plotted Data from Table E-1

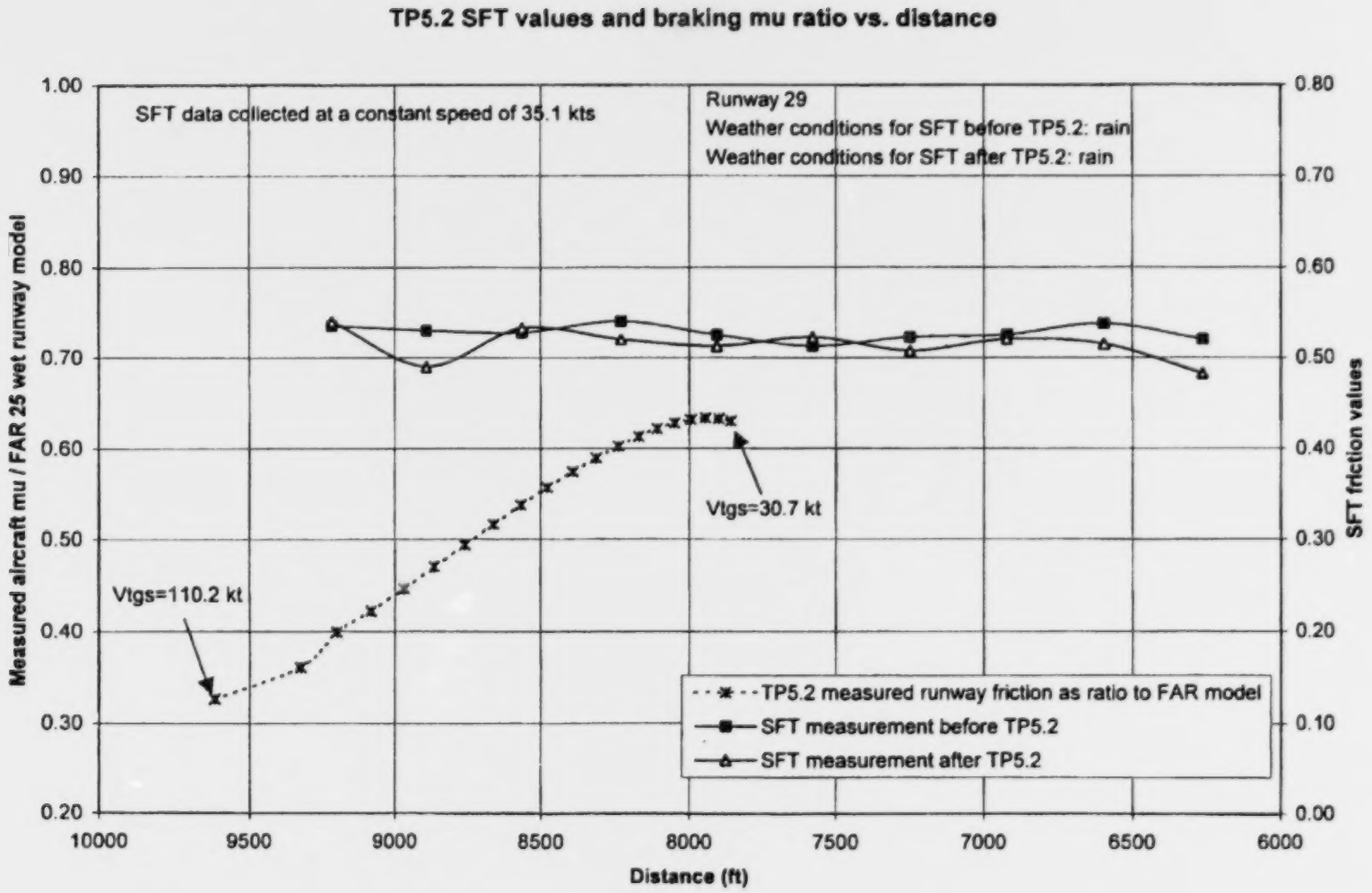


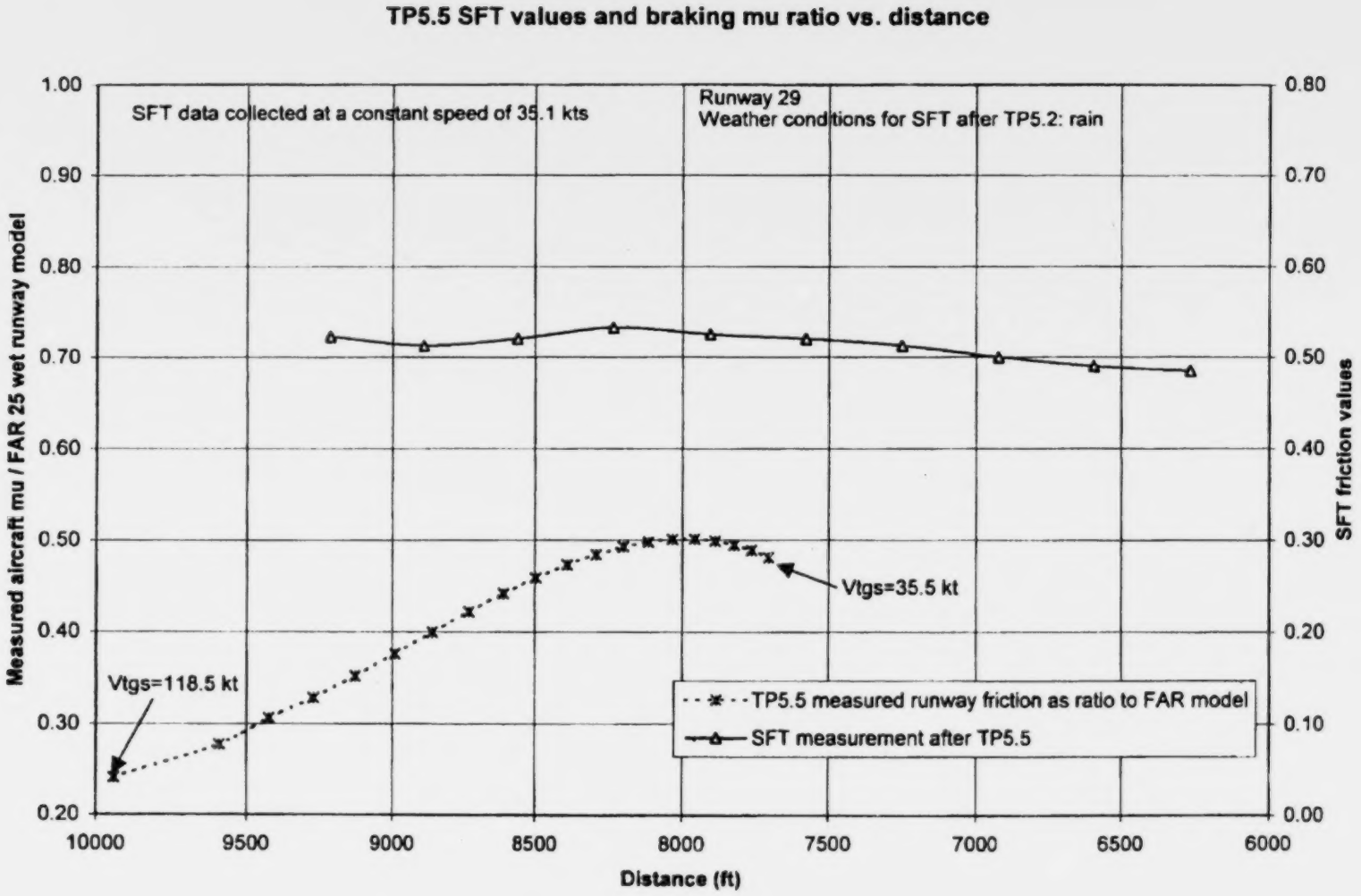



TP4.1 SFT values and braking mu ratio vs. distance
SFT data collected at a constant speed of 35.1 kts
Runway 11
Weather conditions for SFT before TP4.1: Tanker wet and rain
Weather conditions for SFT after TP4.1: rain
Vtgs=121.1 kt
Vtgs=28.5 kt
TP4.1 measured runway friction as ratio to FAR model
SFT measurement before TP4.1
SFT measurement after TP4.1
Measured aircraft mu / FAR 25 wet runway model
SFT friction values
Distance (ft)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1000
1500
2000
2500
3000
3500
4000


TP4.2 SFT values and braking mu ratio vs. distance
SFT data collected at a constant speed of 35.1 kts
Runway 11
Weather conditions for SFT before TP4.2: rain
Weather conditions for SFT after TP4.2: heavy rain
Vtgs=26.6 kt
Vtgs=104.3 kt
TP4.2 measured runway friction as ratio to FAR model
SFT measurement before TP4.2
SFT measurement after TP4.2
Measured aircraft mu / FAR 25 wet runway model
SFT friction values
Distance (ft)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1000
1500
2000
2500
3000
3500
4000
4500
5000


TP5.1 SFT values and braking mu ratio vs. distance
SFT data collected at a constant speed of 35.1 kts
Runway 11
Weather conditions for SFT after TP5.1: rain
Vtgs=104.0 kt
Vtgs=31.5 kt
TP5.1 measured runway friction as ratio to FAR model
SFT measurement after TP5.1
Measured aircraft mu / FAR 25 wet runway model
SFT friction values
Distance (ft)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1500
2000
2500
3000
3500
4000
4500
5000


TP5.2 SFT values and braking mu ratio vs. distance
SFT data collected at a constant speed of 35.1 kts
Runway 29
Weather conditions for SFT before TP5.2: rain
Weather conditions for SFT after TP5.2: rain
Vtgs=110.2 kt
Vtgs=30.7 kt
TP5.2 measured runway friction as ratio to FAR model
SFT measurement before TP5.2
SFT measurement after TP5.2
Measured aircraft mu / FAR 25 wet runway model
SFT friction values
Distance (ft)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
10000
9500
9000
8500
8000
7500
7000
6500
6000


TP5.5 SFT values and braking mu ratio vs. distance
SFT data collected at a constant speed of 35.1 kts
Runway 29
Weather conditions for SFT after TP5.2: rain
Measured aircraft mu / FAR 25 wet runway model
SFT friction values
Distance (ft)
Vtgs=118.5 kt
Vtgs=35.5 kt
TP5.5 measured runway friction as ratio to FAR model
SFT measurement after TP5.5
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
10000
9500
9000
8500
8000
7500
7000
6500
6000

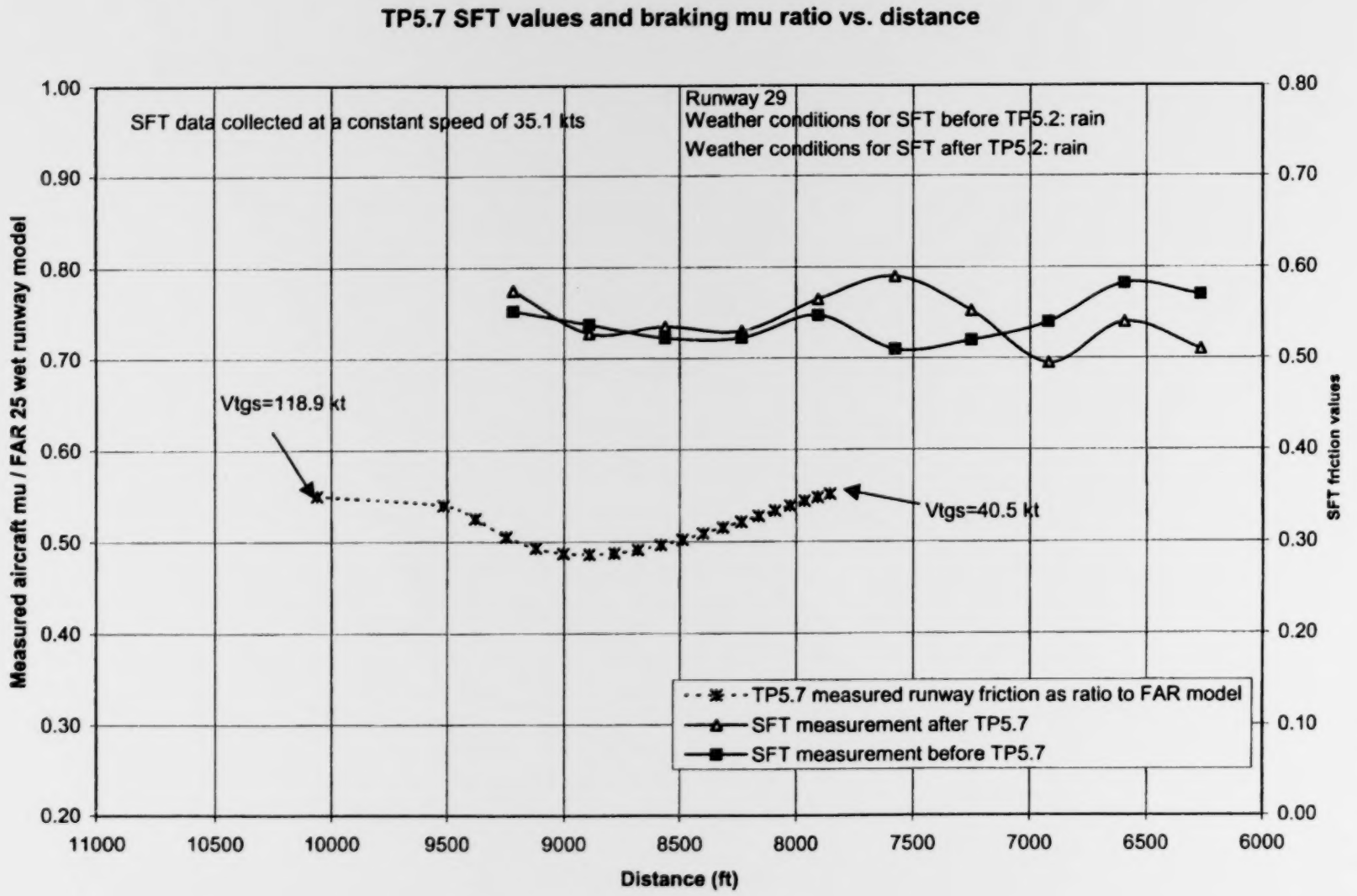

TP5.7 SFT values and braking mu ratio vs. distance
SFT data collected at a constant speed of 35.1 kts
Runway 29
Weather conditions for SFT before TP5.2: rain
Weather conditions for SFT after TP5.2: rain
Vtgs=118.9 kt
Vtgs=40.5 kt
TP5.7 measured runway friction as ratio to FAR model
SFT measurement after TP5.7
SFT measurement before TP5.7
Measured aircraft mu / FAR 25 wet runway model
SFT friction values
Distance (ft)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
11000
10500
10000
9500
9000
8500
8000
7500
7000
6500
6000

Table E-2: Transport Canada SFT900 and Tradewind SFT Friction Test Results - Mirabel Airport (September 8, 2005)

					Chainage (m)		TC Friction Measurements			Tradewind Friction Measurements		
Start Time	Runway	Test Section Length (m)	Test Section Condition	Test Speed (km/h)	From	To	Run 1	Run 2	Average	Run 1	Run 2	Average
12:12	11 End	700	Tanker Wet & Rain	65	5+500	5+600	0.67	0.49	0.58	0.79	0.65	0.72
					5+600	5+700	0.80	0.41	0.61	0.57	0.50	0.54
					5+700	5+800	0.55	0.54	0.55	0.32	0.49	0.41
					5+800	5+900	0.35	0.60	0.48	0.52	0.51	0.52
					5+900	6+000	0.35	0.76	0.56	0.62	0.51	0.57
					6+000	6+100	0.50	0.70	0.60	0.69	0.57	0.63
					6+100	6+200	0.61	0.71	0.66	0.65	0.63	0.64
					Average		0.55	0.60	0.57	0.59	0.55	0.57
12:22	11 End	700	Rain	65	5+500	5+600	0.64	0.53	0.59	0.71	0.55	0.63
					5+600	5+700	0.45	0.35	0.40	0.50	0.42	0.46
					5+700	5+800	0.29	0.35	0.32	0.41	0.41	0.41
					5+800	5+900	0.41	0.42	0.42	0.54	0.49	0.52
					5+900	6+000	0.47	0.61	0.54	0.46	0.47	0.47
					6+000	6+100	0.57	0.69	0.63	0.48	0.50	0.49
					6+100	6+200	0.57	0.60	0.59	0.45	0.59	0.52
					Average		0.49	0.51	0.50	0.51	0.49	0.50

Table E-2: Transport Canada SFT900 and Tradewind SFT Friction Test Results - Mirabel Airport (September 8, 2005)

					Chainage (m)		TC Friction Measurements			Tradewind Friction Measurements		
Start Time	Runway	Test Section Length (m)	Test Section Condition	Test Speed (km/h)	From	To	Run 1	Run 2	Average	Run 1	Run 2	Average
12:30	11 End	1000	Heavy Rain	65	5+500	5+600	0.57	0.40	0.49	0.63	0.55	0.59
					5+600	5+700	0.43	0.24	0.34	0.40	0.37	0.39
					5+700	5+800	0.31	0.41	0.36	0.27	0.32	0.30
					5+800	5+900	0.35	0.43	0.39	0.41	0.43	0.42
					5+900	6+000	0.44	0.53	0.49	0.35	0.42	0.39
					6+000	6+100	0.44	0.56	0.50	0.46	0.50	0.48
					6+100	6+200	0.47	0.45	0.46	0.56	0.52	0.54
					6+200	6+300	0.52	0.48	0.50	0.48	0.54	0.51
					6+300	6+400	0.46	0.52	0.49	0.45	0.51	0.48
					6+400	6+500	0.42	0.54	0.48	0.48	0.51	0.50
					Average		0.44	0.46	0.45	0.45	0.47	0.46
12:53	11 End	1000	Rain	65	5+500	5+600	0.67	0.57	0.62	0.69	0.38	0.54
					5+600	5+700	0.46	0.35	0.41	0.47	0.34	0.41
					5+700	5+800	0.23	0.46	0.35	0.29	0.42	0.36
					5+800	5+900	0.37	0.53	0.45	0.40	0.53	0.47
					5+900	6+000	0.44	0.61	0.53	0.45	0.44	0.45
					6+000	6+100	0.47	0.62	0.55	0.46	0.48	0.47
					6+100	6+200	0.56	0.65	0.61	0.49	0.53	0.51
					6+200	6+300	0.51	0.62	0.57	0.46	0.59	0.53
					6+300	6+400	0.52	0.59	0.56	0.52	0.61	0.57
					6+400	6+500	0.48	0.58	0.53	0.60	0.53	0.57
					Average		0.47	0.56	0.51	0.48	0.49	0.48

Table E-2: Transport Canada SFT900 and Tradewind SFT Friction Test Results - Mirabel Airport (September 8, 2005)

					Chainage (m)		TC Friction Measurements			Tradewind Friction Measurements		
Start Time	Runway	Test Section Length (m)	Test Section Condition	Test Speed (km/h)	From	To	Run 1	Run 2	Average	Run 1	Run 2	Average
13:08	29 End	1000	Rain	65	6+800	6+900	0.52	0.53	0.53	0.55	0.54	0.55
					6+900	7+000	0.60	0.47	0.54	0.51	0.54	0.53
					7+000	7+100	0.60	0.46	0.53	0.51	0.54	0.53
					7+100	7+200	0.55	0.47	0.51	0.62	0.52	0.57
					7+200	7+300	0.59	0.44	0.52	0.57	0.50	0.54
					7+300	7+400	0.66	0.41	0.54	0.50	0.48	0.49
					7+400	7+500	0.61	0.44	0.53	0.49	0.55	0.52
					7+500	7+600	0.60	0.44	0.52	0.48	0.58	0.53
					7+600	7+700	0.59	0.46	0.53	0.53	0.57	0.55
					7+700	7+800	0.53	0.50	0.52	0.55	0.50	0.53
					Average		0.58	0.46	0.52	0.53	0.53	0.53
13:18	29 End	1000	Rain	65	6+800	6+900	0.54	0.47	0.51	0.61	0.54	0.58
					6+900	7+000	0.56	0.42	0.49	0.48	0.50	0.49
					7+000	7+100	0.58	0.45	0.52	0.61	0.49	0.55
					7+100	7+200	0.52	0.47	0.50	0.59	0.50	0.55
					7+200	7+300	0.57	0.45	0.51	0.58	0.45	0.52
					7+300	7+400	0.62	0.46	0.54	0.50	0.51	0.51
					7+400	7+500	0.61	0.43	0.52	0.49	0.50	0.50
					7+500	7+600	0.64	0.46	0.55	0.45	0.53	0.49
					7+600	7+700	0.62	0.47	0.55	0.47	0.50	0.49
					7+700	7+800	0.59	0.42	0.51	0.44	0.48	0.46
					Average		0.58	0.45	0.52	0.52	0.50	0.51

Table E-2: Transport Canada SFT900 and Tradewind SFT Friction Test Results - Mirabel Airport (September 8, 2005)

					Chainage (m)		TC Friction Measurements			Tradewind Friction Measurements		
Start Time	Runway	Test Section Length (m)	Test Section Condition	Test Speed (km/h)	From	To	Run 1	Run 2	Average	Run 1	Run 2	Average
13:31	29 End	1000	Rain	65	6+800	6+900	0.50	0.55	0.53	0.52	0.53	0.53
					6+900	7+000	0.53	0.55	0.54	0.50	0.54	0.52
					7+000	7+100	0.51	0.53	0.52	0.51	0.59	0.55
					7+100	7+200	0.45	0.47	0.46	0.53	0.46	0.50
					7+200	7+300	0.56	0.54	0.55	0.59	0.50	0.55
					7+300	7+400	0.55	0.51	0.53	0.62	0.53	0.58
					7+400	7+500	0.49	0.54	0.52	0.49	0.60	0.55
					7+500	7+600	0.49	0.53	0.51	0.46	0.58	0.52
					7+600	7+700	0.46	0.53	0.50	0.57	0.56	0.57
					7+700	7+800	0.42	0.60	0.51	0.56	0.48	0.52
					Average		0.49	0.54	0.51	0.54	0.54	0.54
13:47	29 End	1000	Rain	65	6+800	6+900	0.55	0.53	0.54	0.50	0.60	0.55
					6+900	7+000	0.62	0.51	0.57	0.50	0.53	0.52
					7+000	7+100	0.59	0.52	0.56	0.63	0.55	0.59
					7+100	7+200	0.58	0.50	0.54	0.51	0.50	0.51
					7+200	7+300	0.60	0.54	0.57	0.56	0.55	0.56
					7+300	7+400	0.64	0.49	0.57	0.65	0.54	0.60
					7+400	7+500	0.59	0.53	0.56	0.54	0.53	0.54
					7+500	7+600	0.68	0.54	0.61	0.50	0.55	0.53
					7+600	7+700	0.64	0.49	0.57	0.63	0.58	0.61
					7+700	7+800	0.62	0.45	0.54	0.54	0.52	0.53
					Average		0.61	0.51	0.56	0.56	0.55	0.55

Table E-2: Transport Canada SFT900 and Tradewind SFT Friction Test Results - Mirabel Airport (September 8, 2005)

					Chainage (m)		TC Friction Measurements			Tradewind Friction Measurements		
Start Time	Runway	Test Section Length (m)	Test Section Condition	Test Speed (km/h)	From	To	Run 1	Run 2	Average	Run 1	Run 2	Average
14:09	29 End	1000	Rain	65	6+800	6+900	0.52	0.45	0.49	0.57	0.55	0.56
					6+900	7+000	0.60	0.45	0.53	0.48	0.52	0.50
					7+000	7+100	0.53	0.46	0.50	0.59	0.50	0.55
					7+100	7+200	0.52	0.48	0.50	0.63	0.50	0.57
					7+200	7+300	0.59	0.44	0.52	0.50	0.57	0.54
					7+300	7+400	0.54	0.48	0.51	0.49	0.57	0.53
					7+400	7+500	0.58	0.42	0.50	0.50	0.55	0.53
					7+500	7+600	0.48	0.48	0.48	0.47	0.57	0.52
					7+600	7+700	0.45	0.44	0.45	0.53	0.54	0.54
					7+700	7+800	0.51	0.52	0.52	0.44	0.47	0.46
					Average		0.53	0.46	0.50	0.52	0.53	0.53
14:18	29 End	1000	Rain	65	6+800	6+900	0.57	0.58	0.58	0.52	0.54	0.53
					6+900	7+000	0.55	0.55	0.55	0.51	0.54	0.53
					7+000	7+100	0.53	0.54	0.54	0.53	0.49	0.51
					7+100	7+200	0.52	0.50	0.51	0.56	0.51	0.54
					7+200	7+300	0.58	0.52	0.55	0.60	0.49	0.55
					7+300	7+400	0.53	0.50	0.52	0.53	0.48	0.51
					7+400	7+500	0.56	0.53	0.55	0.50	0.49	0.50
					7+500	7+600	0.50	0.54	0.52	0.54	0.58	0.56
					7+600	7+700	0.59	0.51	0.55	0.62	0.61	0.62
					7+700	7+800	0.49	0.58	0.54	0.64	0.57	0.61
					Average		0.54	0.54	0.54	0.56	0.53	0.54

Table E-2: Transport Canada SFT900 and Tradewind SFT Friction Test Results - Mirabel Airport (September 8, 2005)

					Chainage (m)		TC Friction Measurements			Tradewind Friction Measurements		
Start Time	Runway	Test Section Length (m)	Test Section Condition	Test Speed (km/h)	From	To	Run 1	Run 2	Average	Run 1	Run 2	Average
14:29	29 End	1000	Rain	65	6+800	6+900	0.65	0.58	0.62	0.50	0.57	0.54
					6+900	7+000	0.57	0.52	0.55	0.50	0.52	0.51
					7+000	7+100	0.52	0.53	0.53	0.56	0.53	0.55
					7+100	7+200	0.51	0.53	0.52	0.57	0.51	0.54
					7+200	7+300	0.66	0.57	0.62	0.51	0.52	0.52
					7+300	7+400	0.71	0.53	0.62	0.62	0.50	0.56
					7+400	7+500	0.64	0.49	0.57	0.55	0.53	0.54
					7+500	7+600	0.46	0.51	0.49	0.46	0.55	0.51
					7+600	7+700	0.57	0.52	0.55	0.49	0.58	0.54
					7+700	7+800	0.52	0.54	0.53	0.49	0.49	0.49
					Average		0.58	0.53	0.56	0.53	0.53	0.53

Table E-3: Landing and Braking Distances for Dry, FAR Wet and Mirabel Wet Runway Braking mu

	Using AFM Dry Runway mu Model		Using FAR Wet Runway mu Model		Using mu Derived for Each Test Point at Mirabel	
Test Point	Total Landing Distances (ft)	Braking Distances (ft)	Total Landing Distances (ft)	Braking Distances (ft)	Total Landing Distances (ft)	Braking Distances (ft)
4.1	2560	1216	3065	1721	3624	2280
4.2	2614	1256	3146	1788	3922	2564
5.1	2569	1223	3079	1733	3572	2226
5.2	2643	1256	3178	1790	3875	2487
5.5	2627	1244	3154	1770	4052	2668
5.7	2601	1225	3115	1739	3787	2410

Note: Distances and factors for test points 5.3 and 5.4 could not be calculated due to test instrumentation problems.